Image-Based Modeling and Photo Editing

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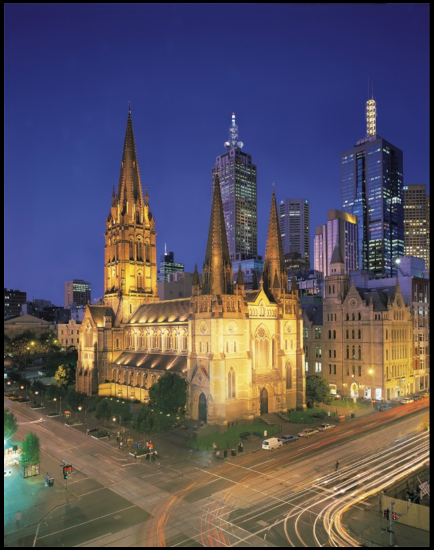
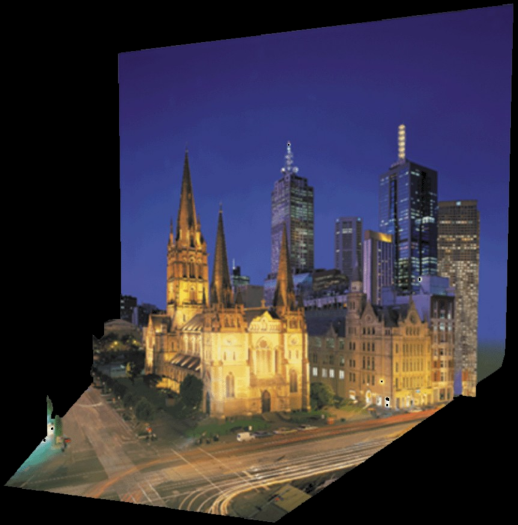
Introduction: Image-Based Editing

Single image as input

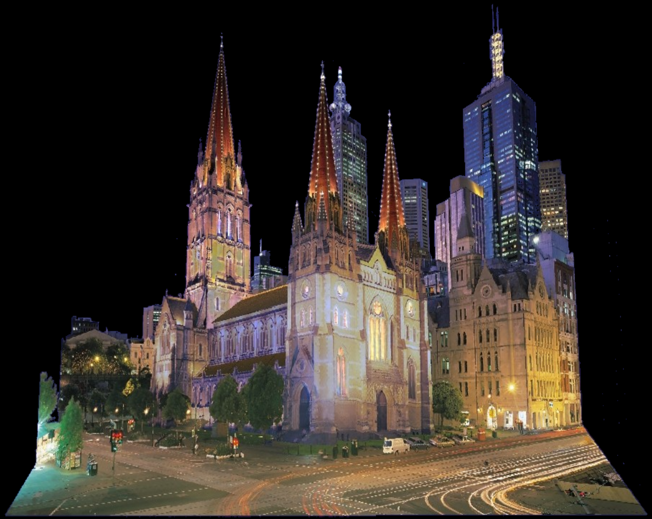
Editing of image-based representation



Input image



New viewpoint



Editing, relighting

Image-Based Modeling & Rendering

Rendering new views

- Chen et al.93, Laveau et al.94, McMillan et al.95, Levoy et al.96, Gortler et al.96, Horry et al.97, Shade et al.98

3D models from photographs

- Debevec et al.96, Faugeras et al.95, Poulin et al.98, Liebowitz et al.99

Unfortunately, little work in editing

- Seitz et al.98

Photo Editing

Powerful *editing* systems

- e.g. Adobe Photoshop, Gimp

Completely based on user intervention

Unfortunately, limitations of 2D

Goal: Best of Both Worlds

Image-based modeling & rendering

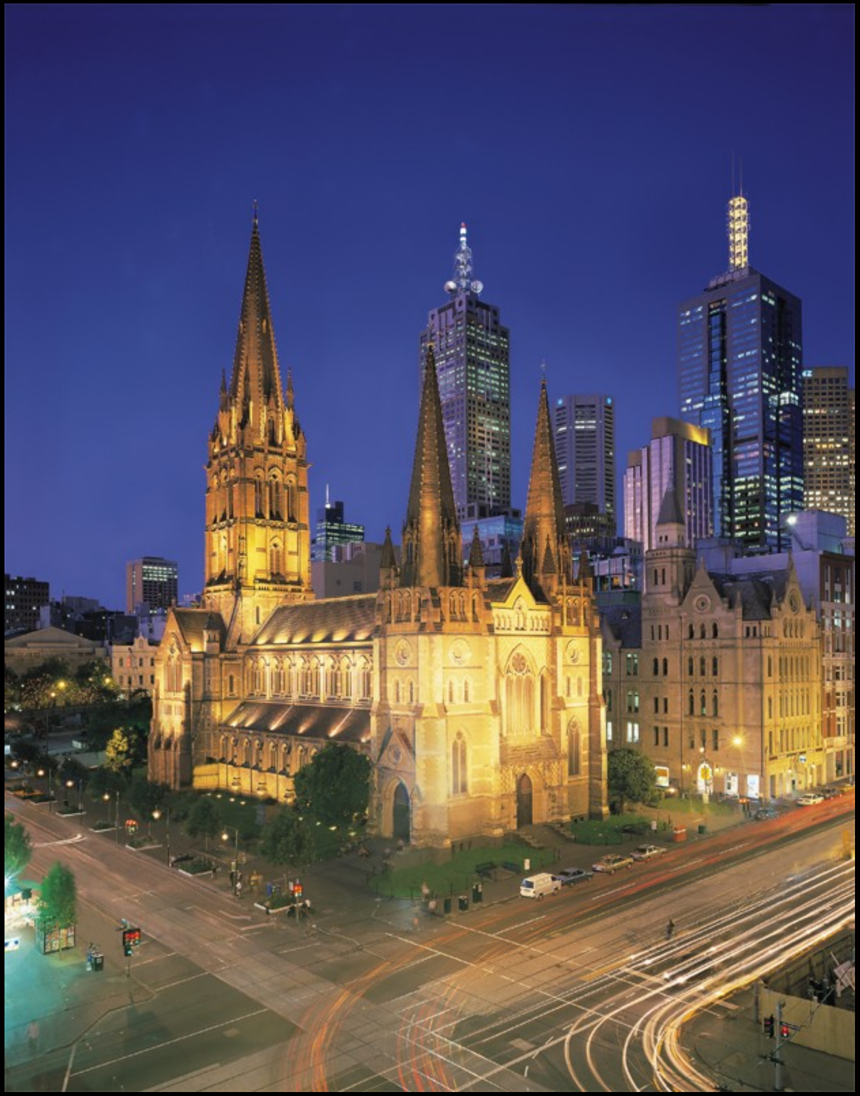
- Capture 3D layout, render new views

Photo editing

- Editing, flexibility, simplicity

Image-based *editing*!

Sample Result of Our System



Input Image, Courtesy of Barry Webb and Assoc.

Outline

Image-based representation & user workflow

Depth assignment

Non-distorted clone brushing

Texture-illuminance decoupling

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Non-distorted clone brushing

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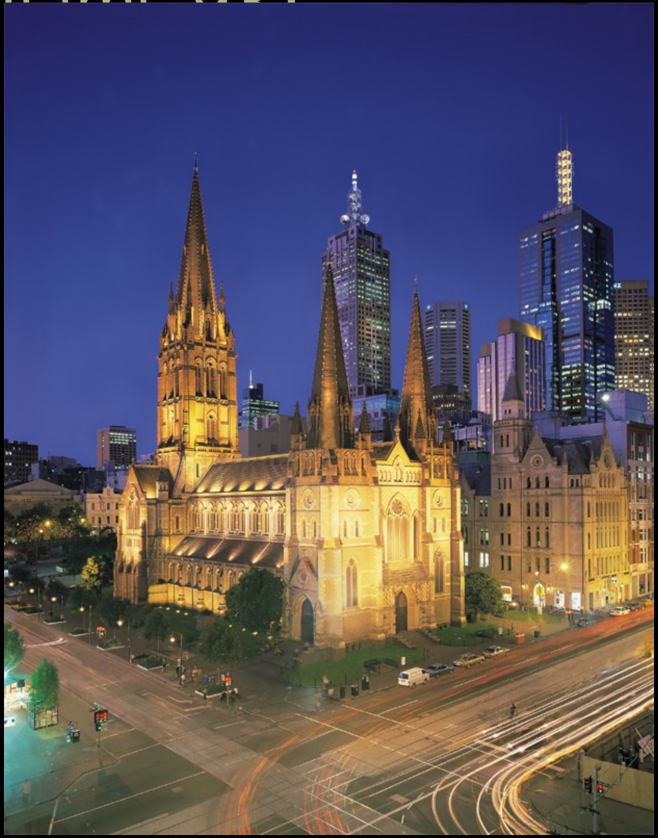
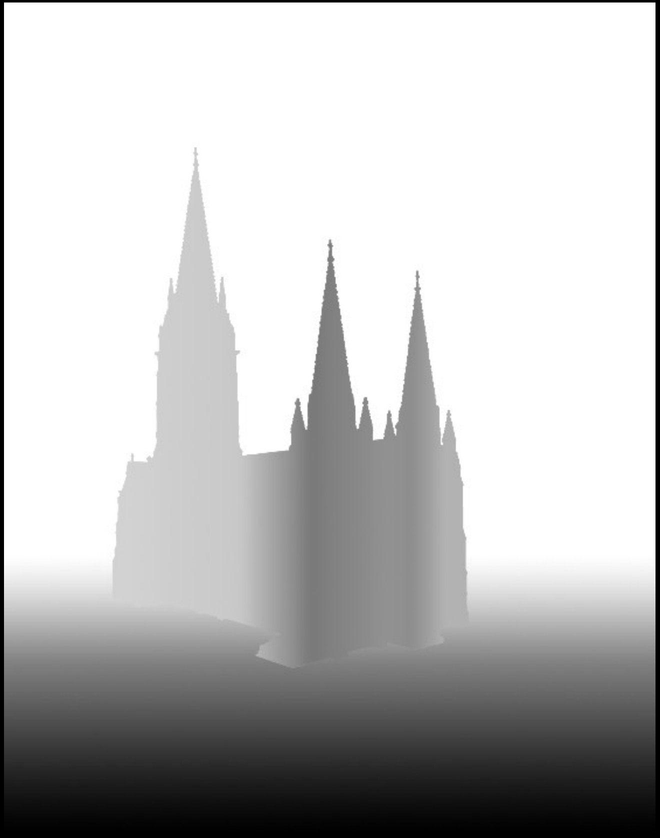
Image-Based Representation

Build upon *images with depth* (Chen & Williams 93)



Color channel



Depth channel

Image-Based Representation

Layers of images with depth

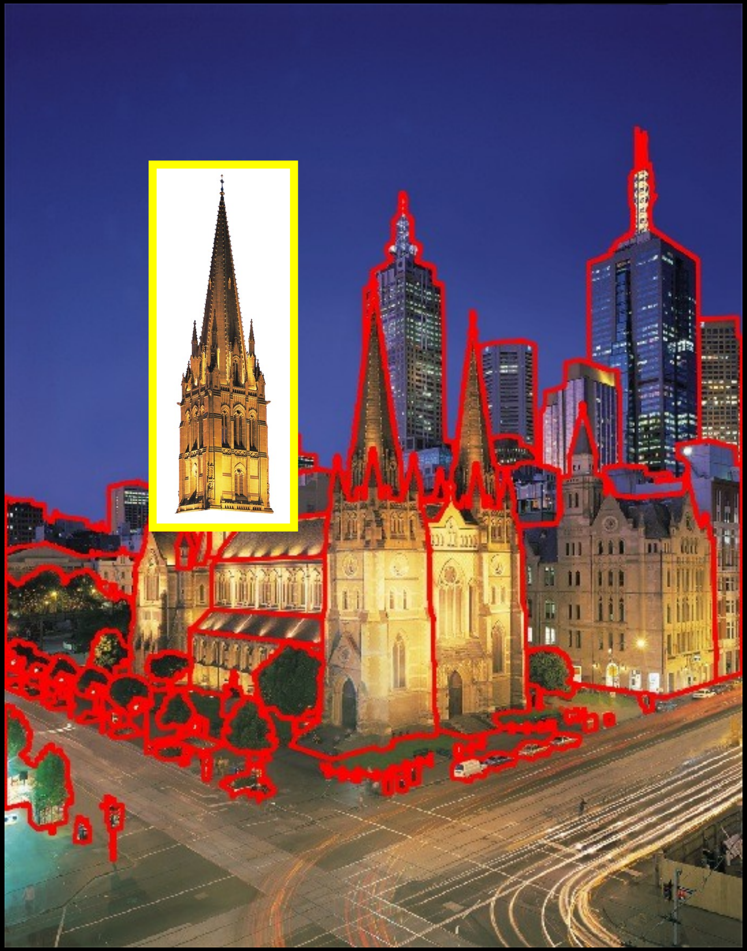


Image-Based Representation

Layers of images with depth

Each layer has

- Color
- Depth
- Transparency

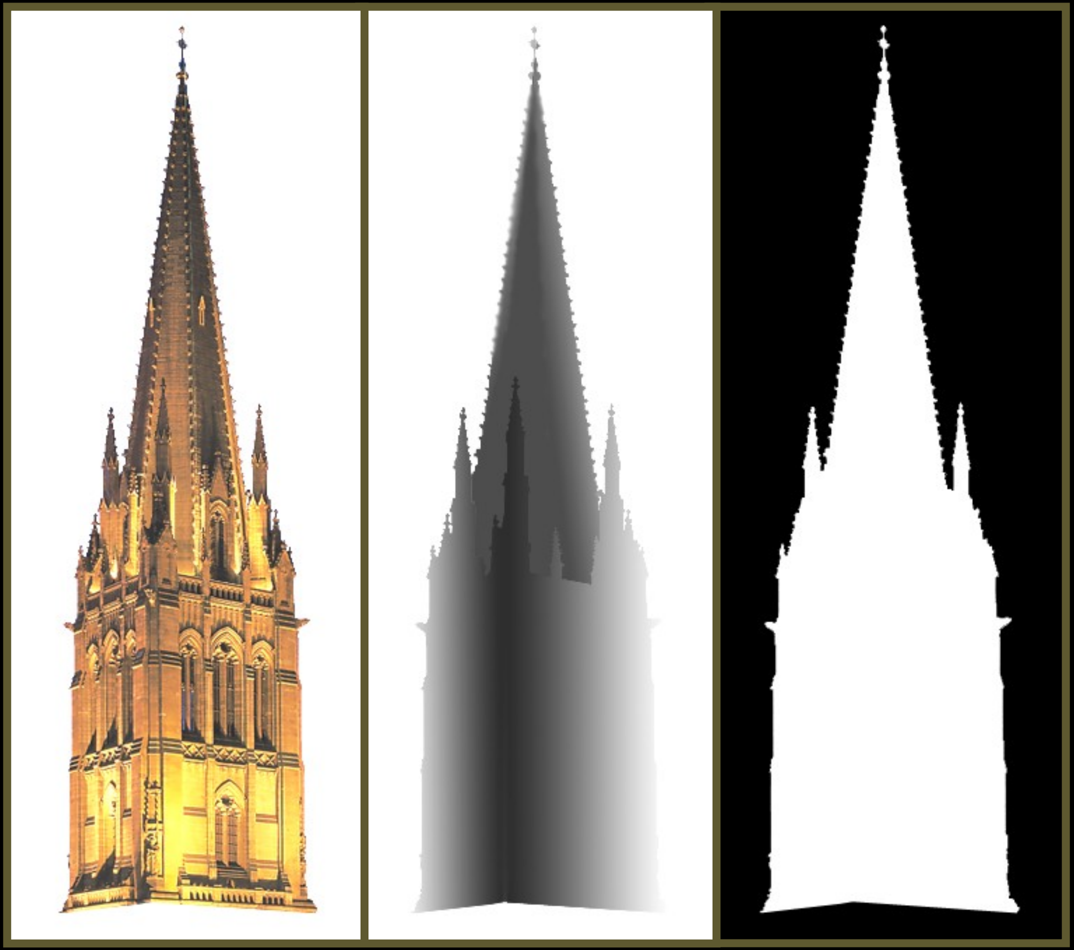


Image-Based Representation

Layers of images with depth

Each layer has

- **Color**
- Depth
- Transparency

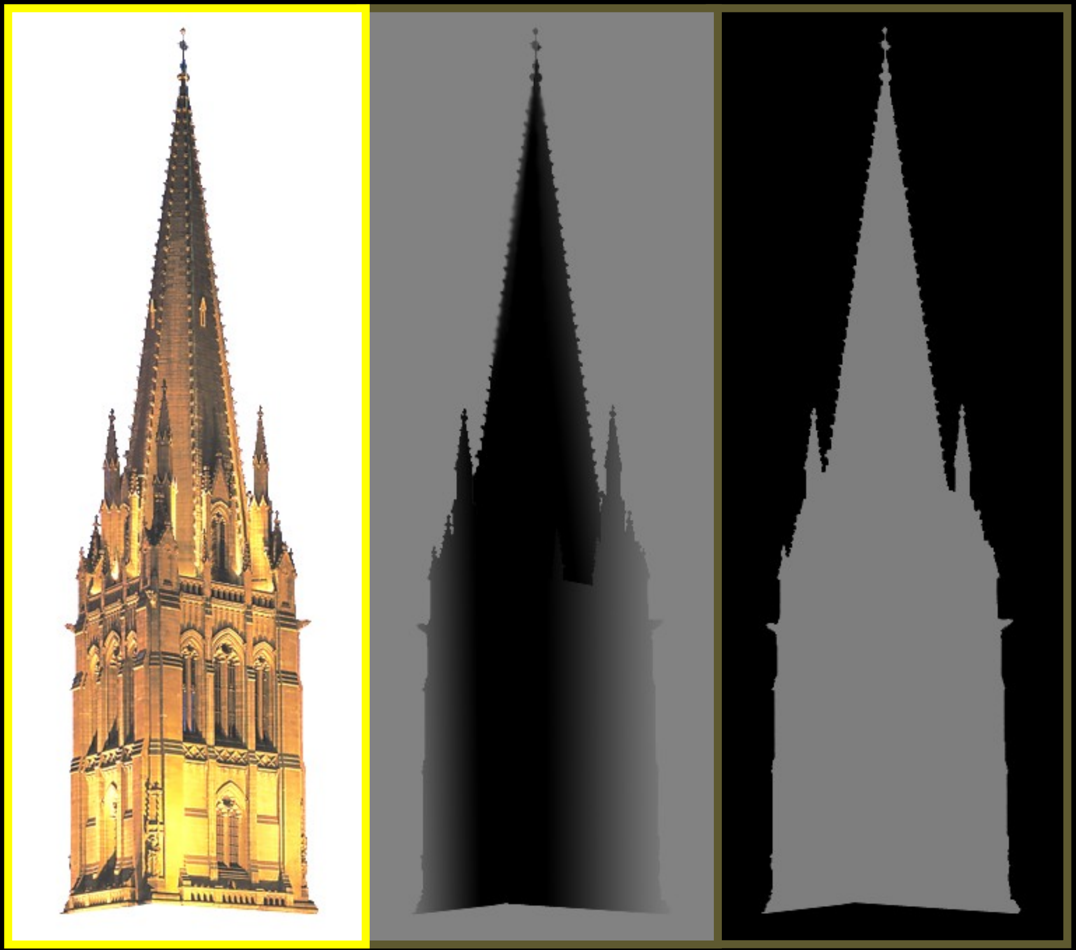


Image-Based Representation

Layers of images with depth

Each layer has

- Color
- **Depth**
- Transparency

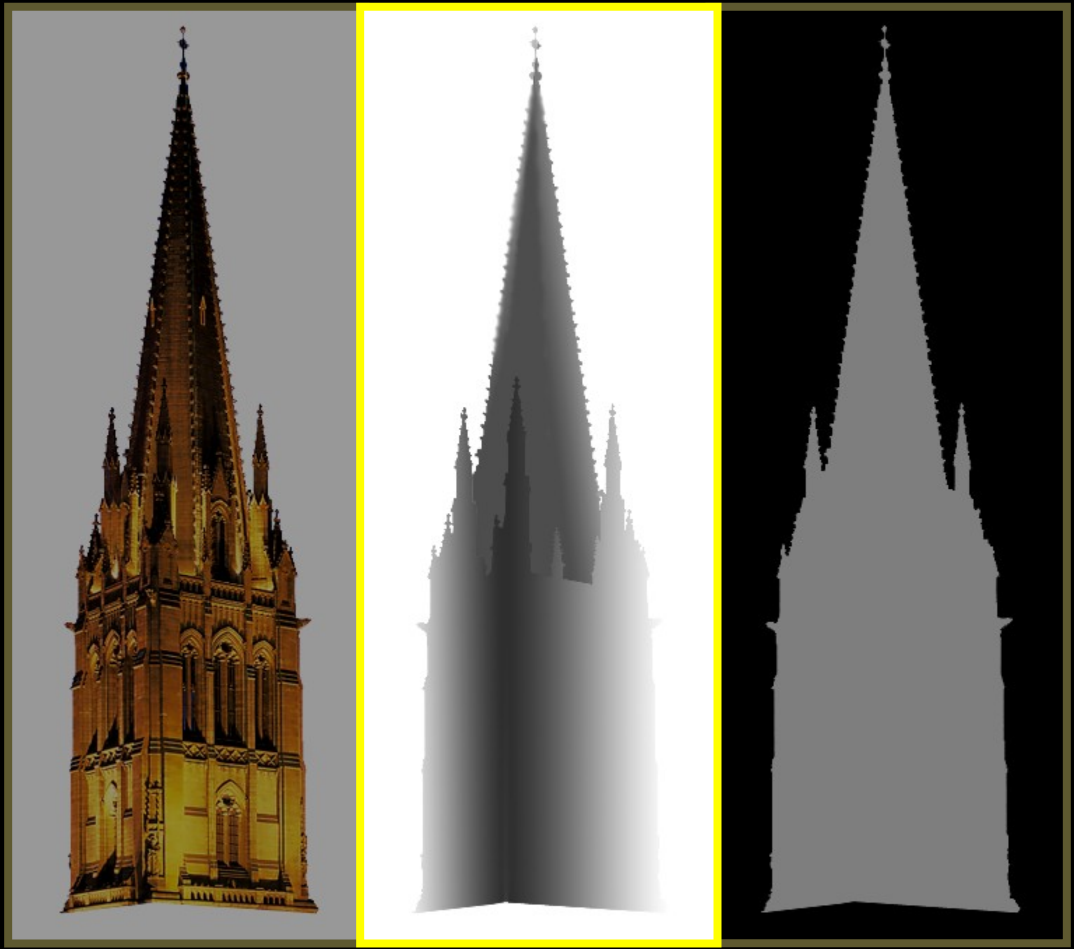


Image-Based Representation

Layers of images with depth

Each layer has

- Color
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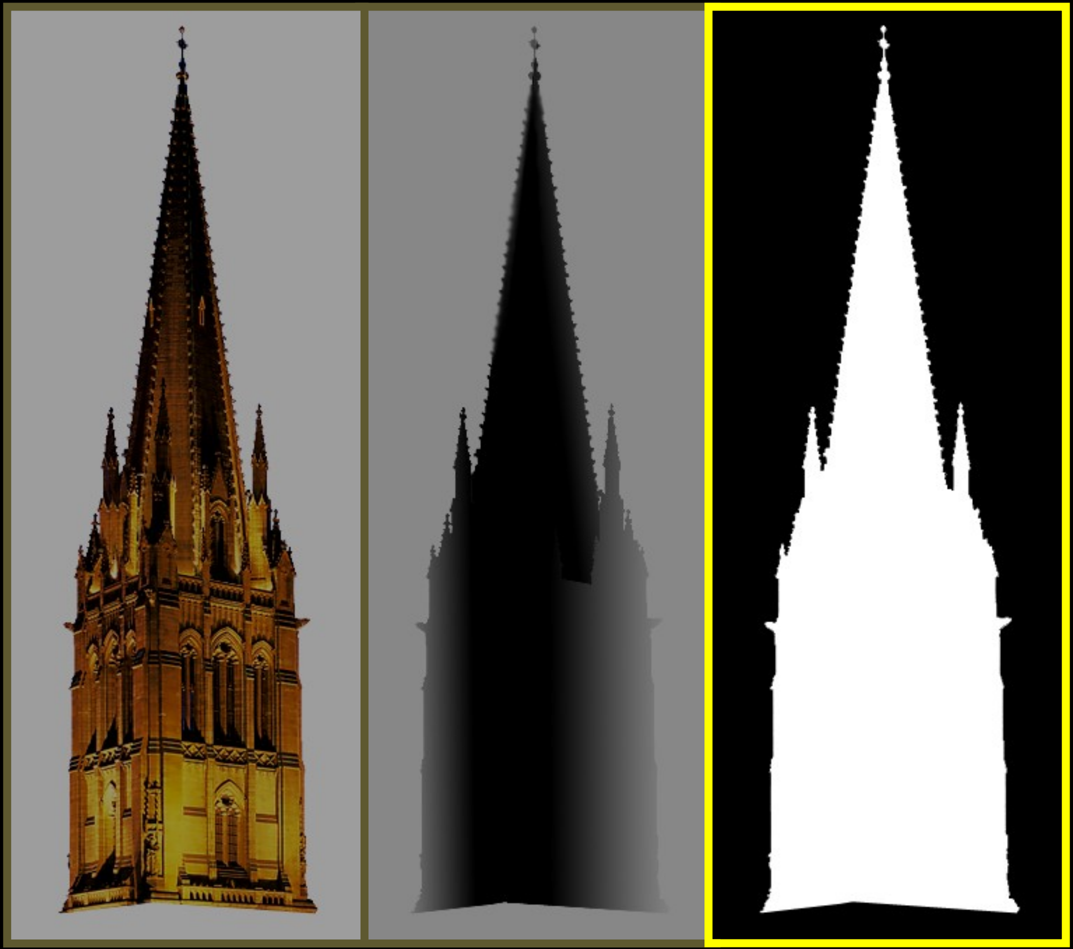
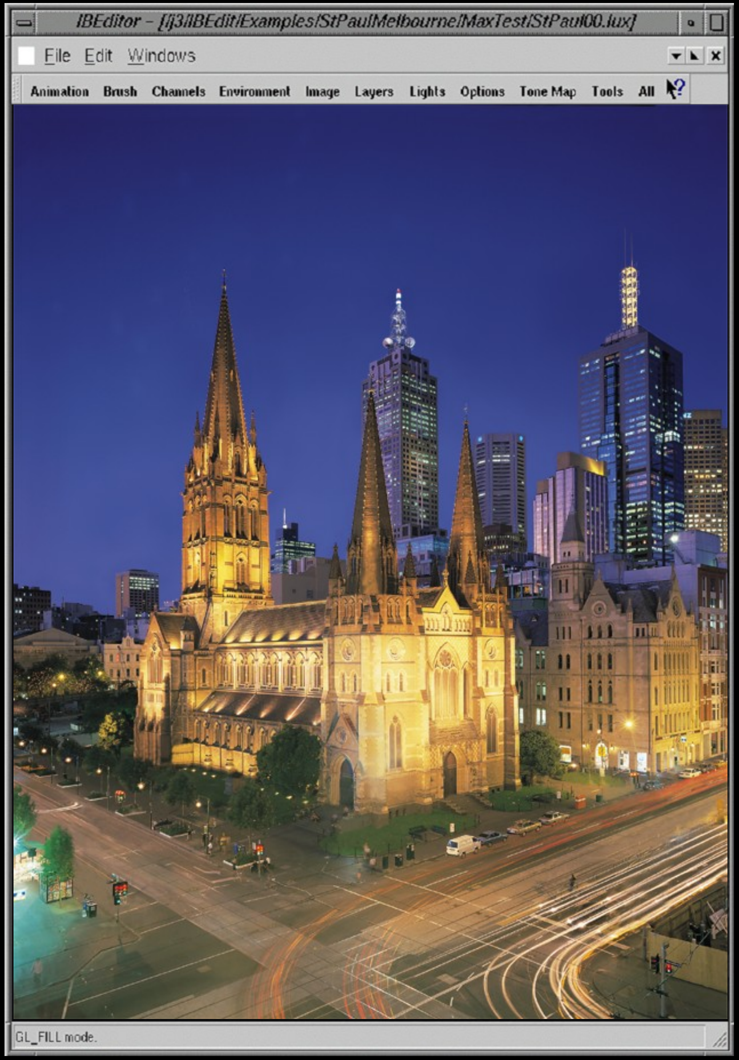
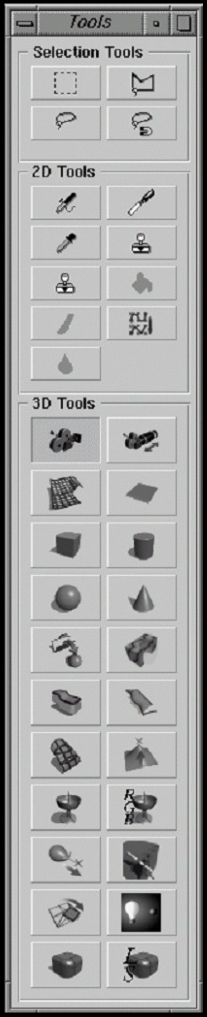
- **Transparency**



Typical User Workflow



GL_FILL mode.



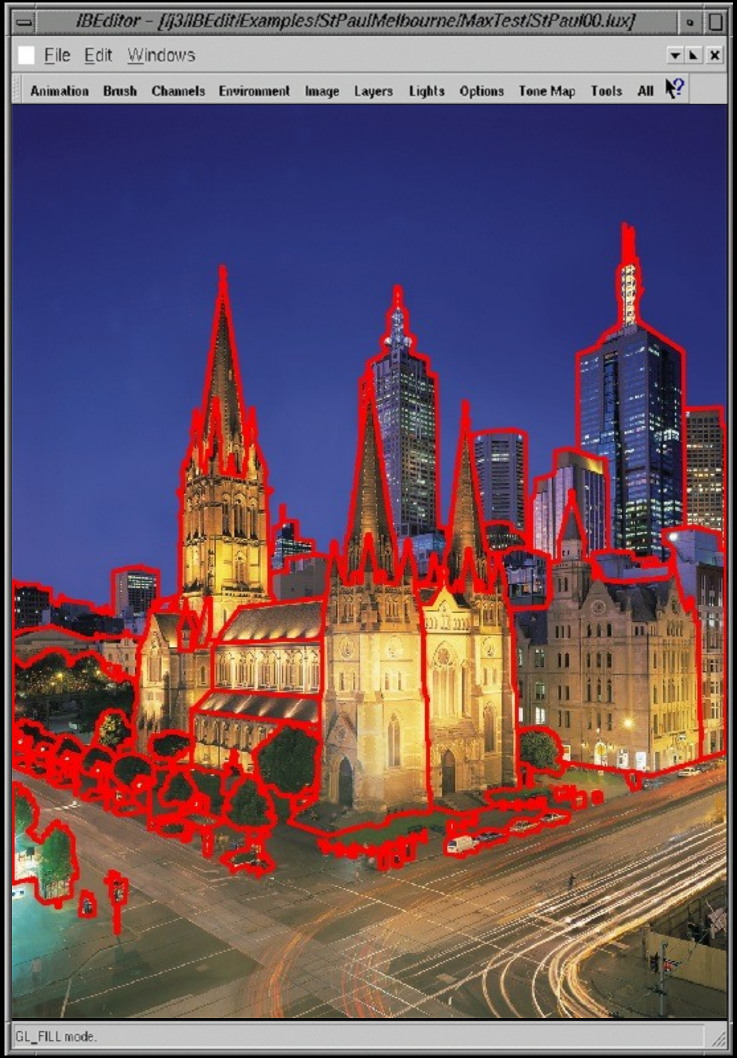
Input image

Typical User Workflow

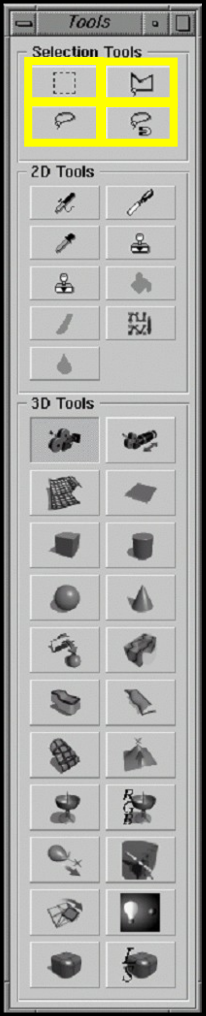
Input image

Typical User Workflow

Input image

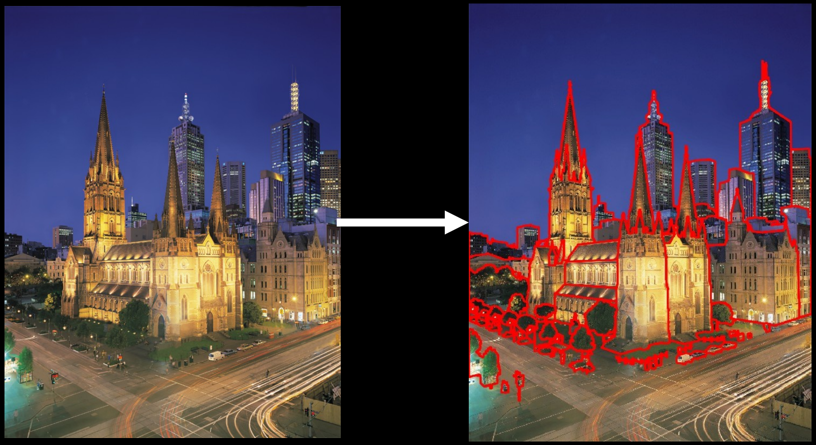

IBEditor - [/j3/IBEdit/Examples/StPaulMelbourne/MaxTest/StPaul00.lux]
File Edit Windows
Animation Brush Channels Environment Image Layers Lights Options Tone Map Tools All

GL_FILL mode.



User segments manually

Typical User Workflow

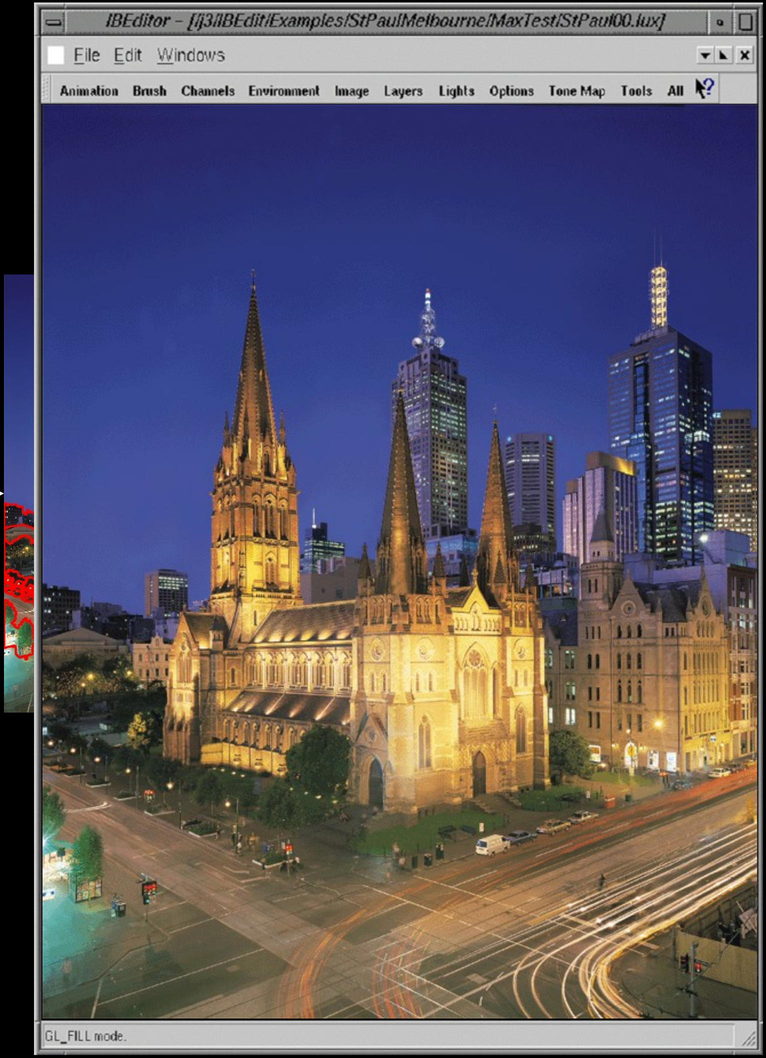


Input image

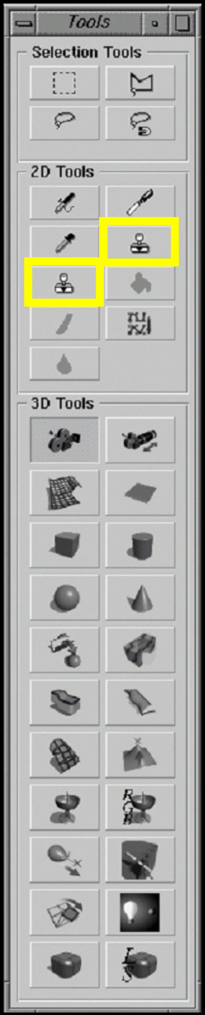
Segment

Typical User Workflow

Input image



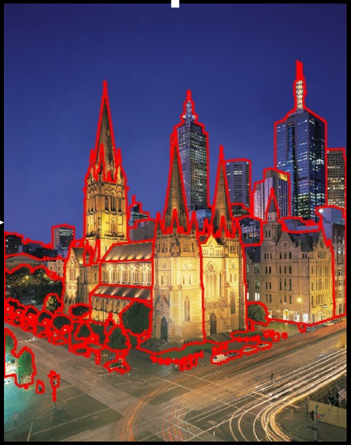
GL_FILL mode.



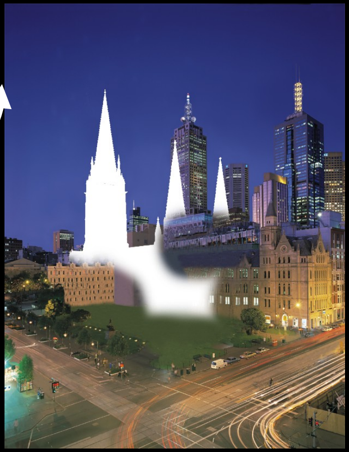
User clone brushes and fills in holes

Typical User Workflow

Input image



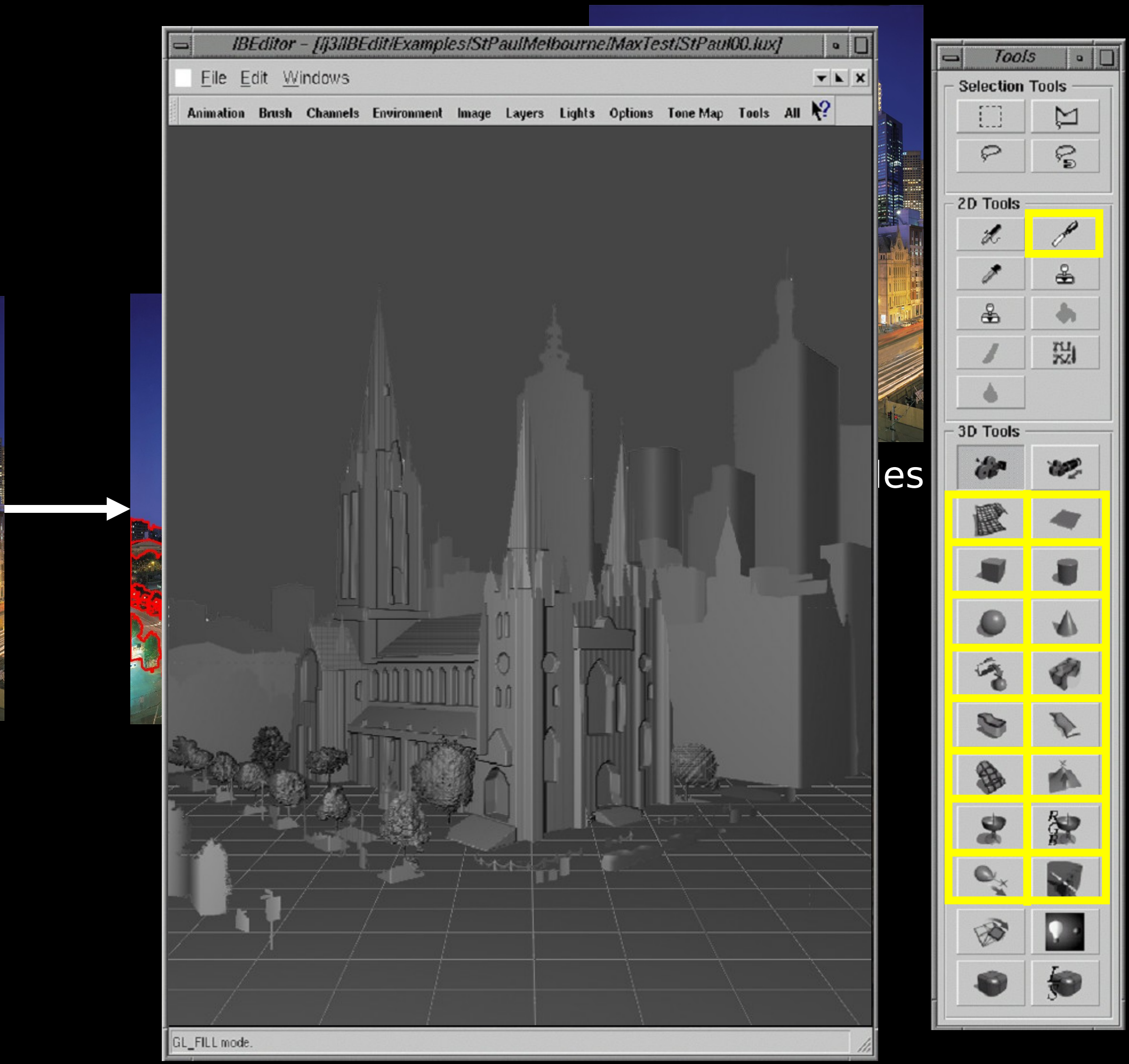
Segment



Clone brush holes

Typical User Workflow

Input image

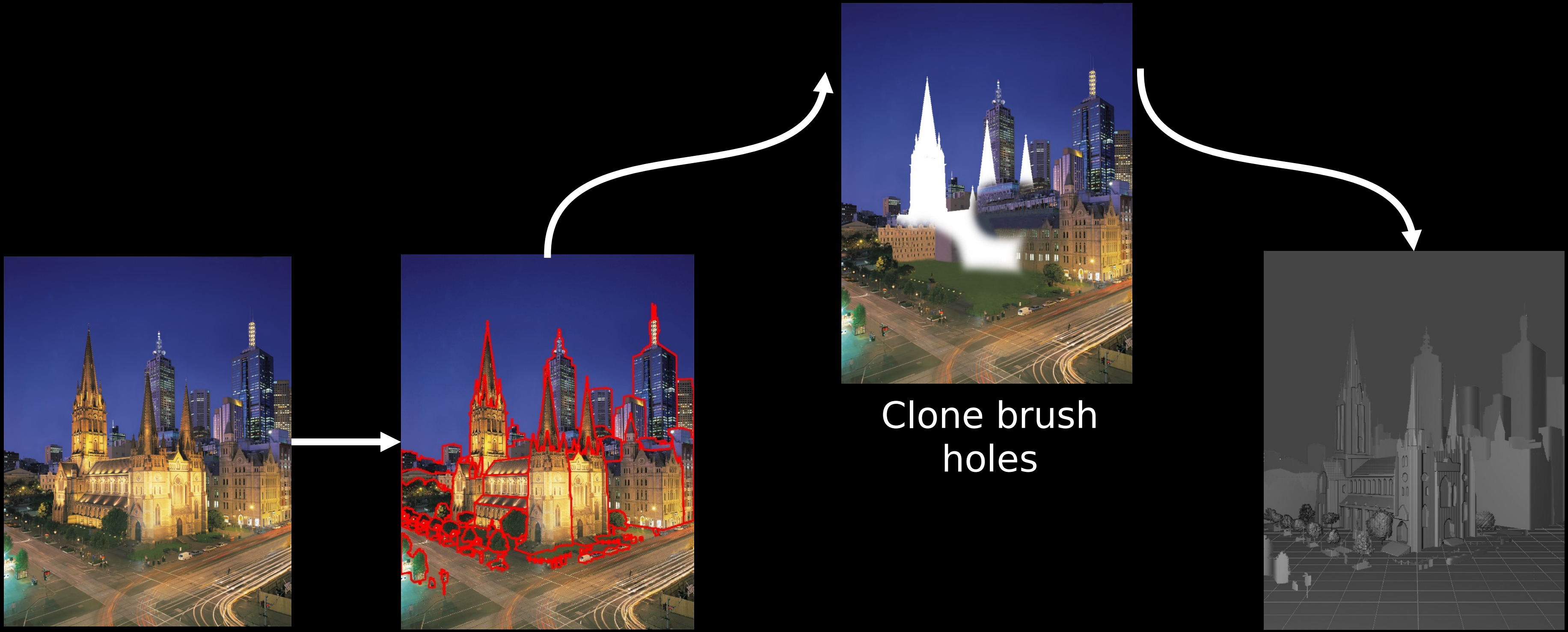


IBEditor - [/j3/IBEdit/Examples/StPaulMelbourne/MaxTest/StPaul00.lux]
File Edit Windows
Animation Brush Channels Environment Image Layers Lights Options Tone Map Tools All
Tools
Selection Tools
2D Tools
3D Tools
es

GL_FILL mode.

User applies depth

Typical User Workflow



Input image

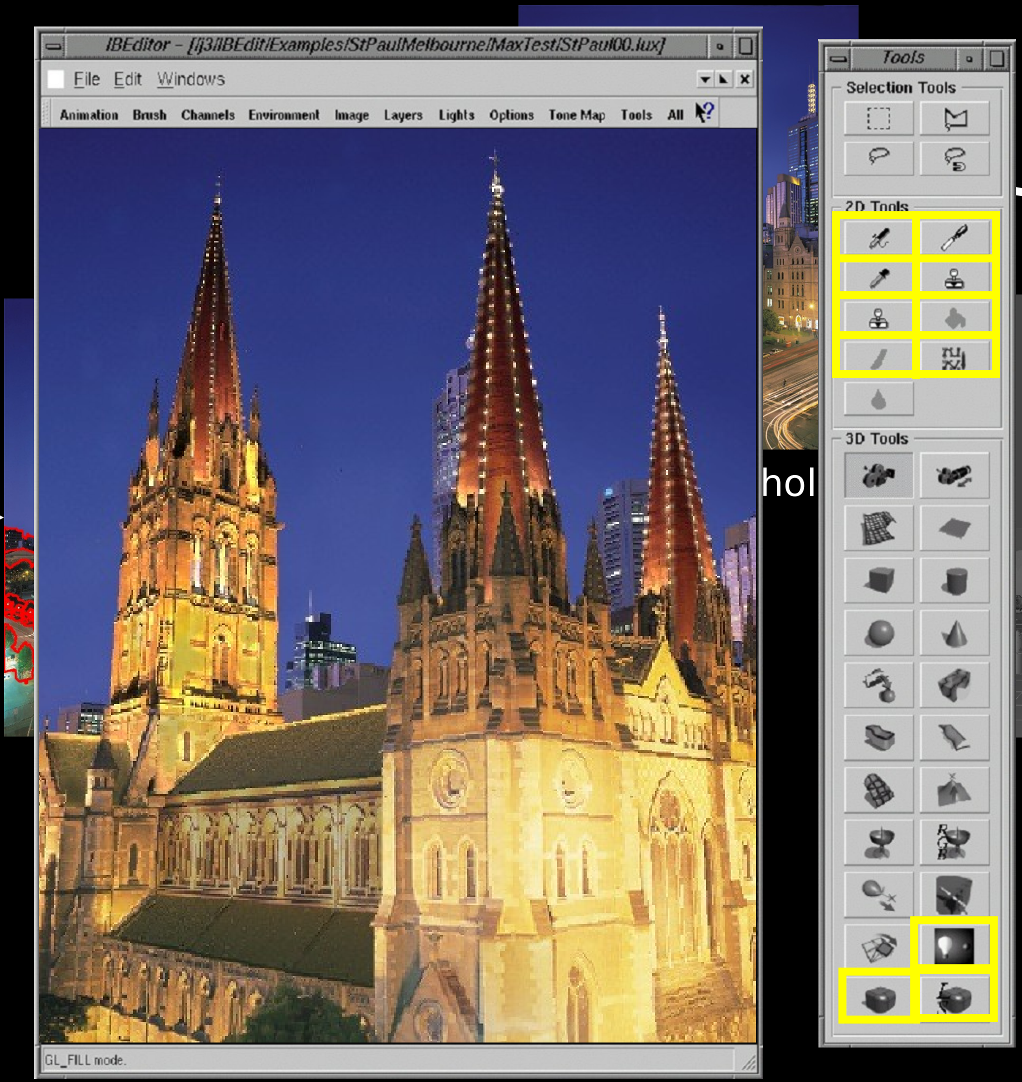
Segment

Clone brush holes

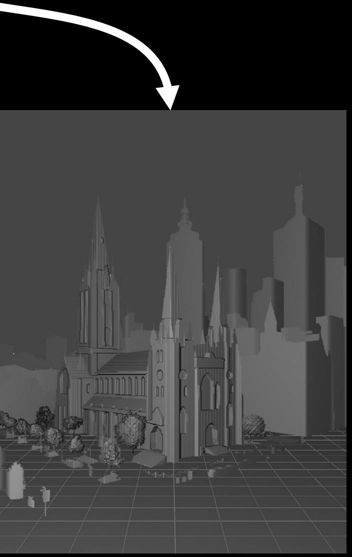
Apply depth

Typical User Workflow

Input image

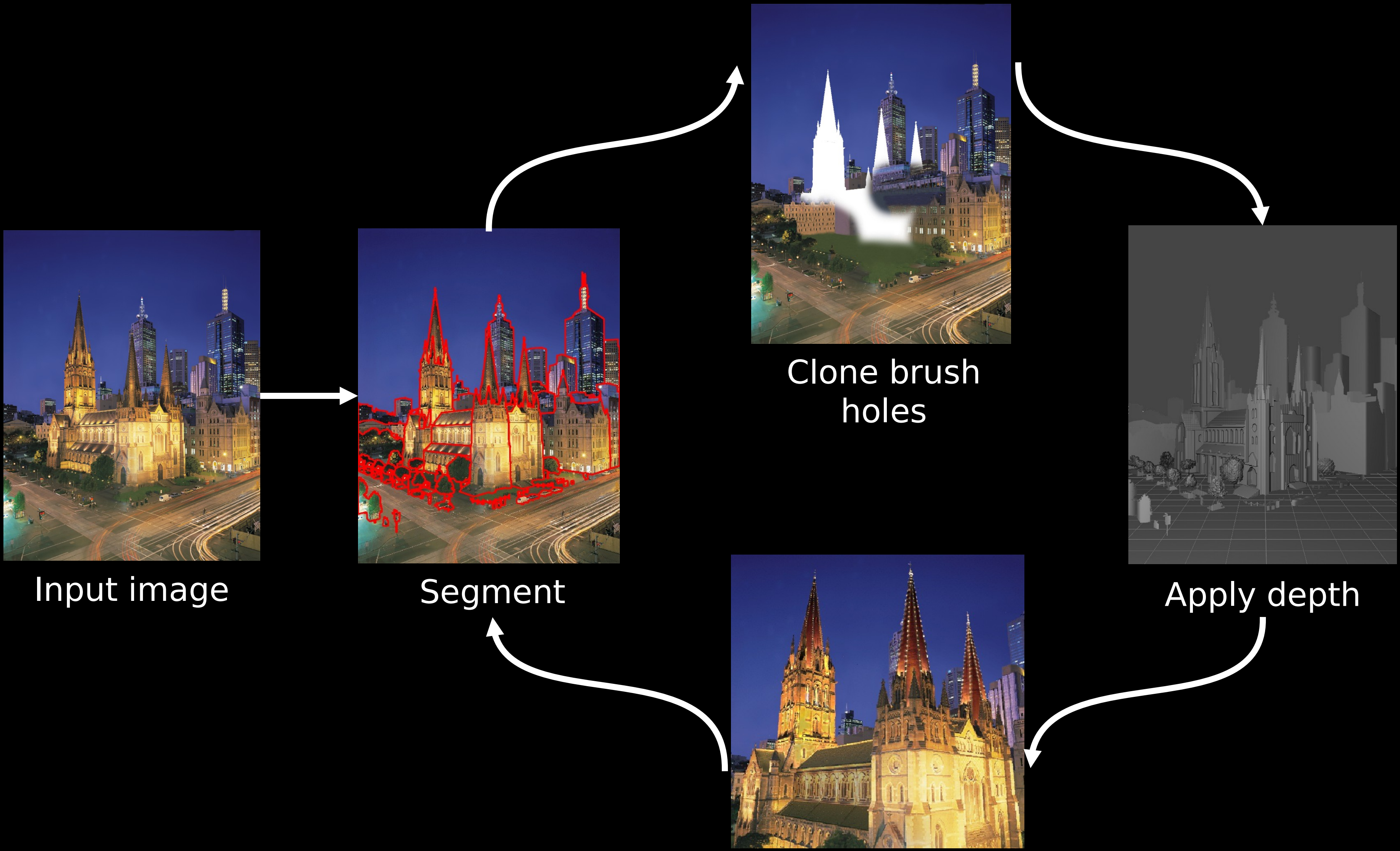

IBEditor – [/j3/IBEdit/Examples/StPaulMelbourne/MaxTest/StPaul00.lux]
File Edit Windows
Animation Brush Channels Environment Image Layers Lights Options Tone Map Tools All
GL_FILL mode.
hol
Tools
Selection Tools
2D Tools
3D Tools

Edit, relight



Apply depth

Typical User Workflow



Input image

Segment

Clone brush holes

Apply depth

Edit, relight

Outline

Image-based representation & user workflow

Depth assignment

Non-distorted clone brushing

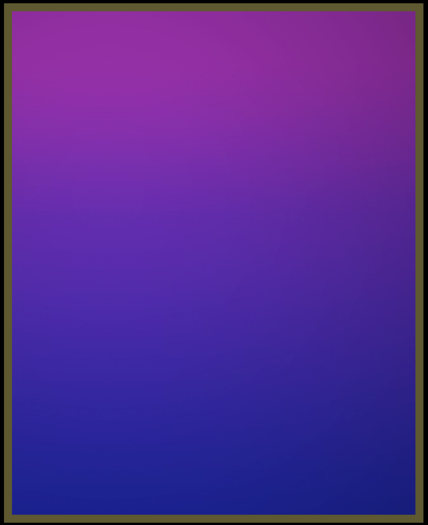
Texture-illuminance decoupling

Depth Assignment Tool

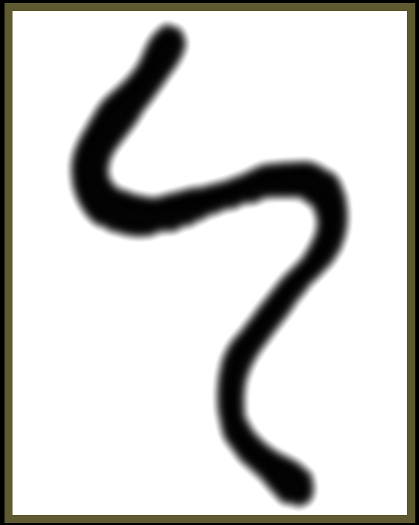
Tool that assigns or modifies the depth of pixels

Similar to tools of 2D phot

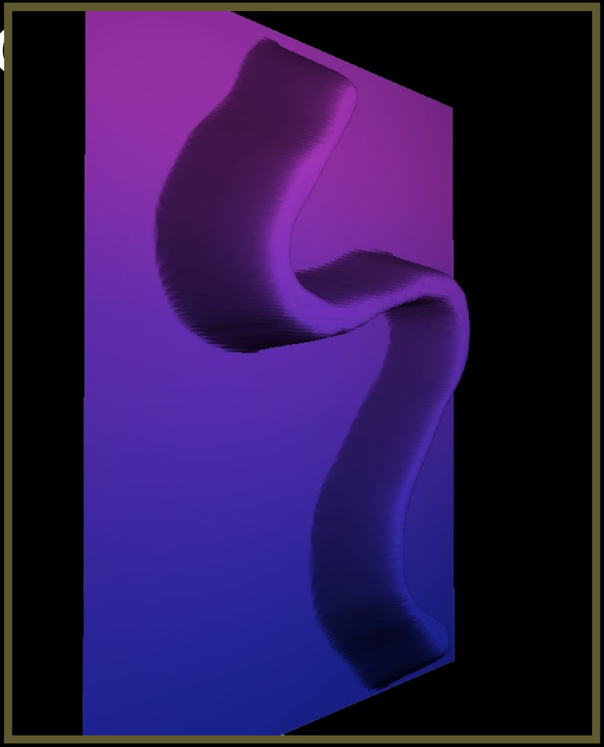
- But on the depth channel



Color channel



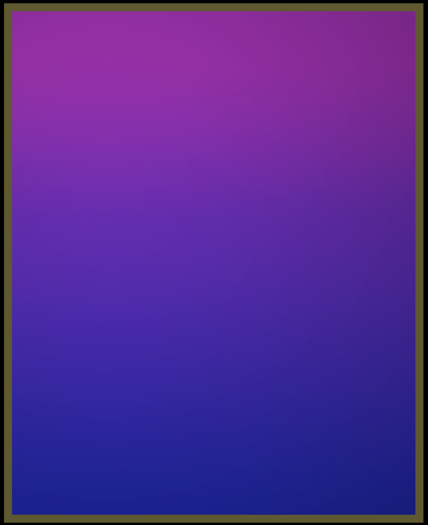
Depth channel



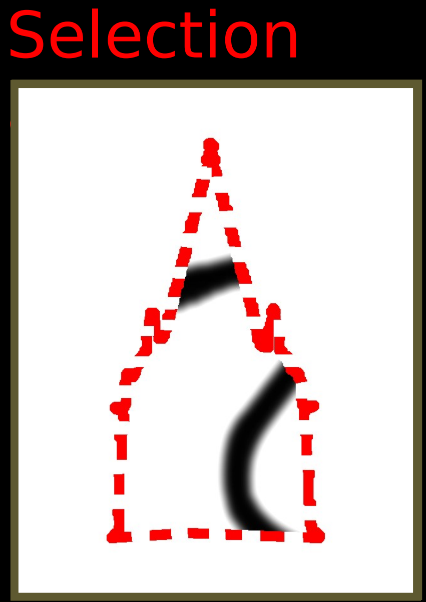
Side view

Depth Assignment and Selection

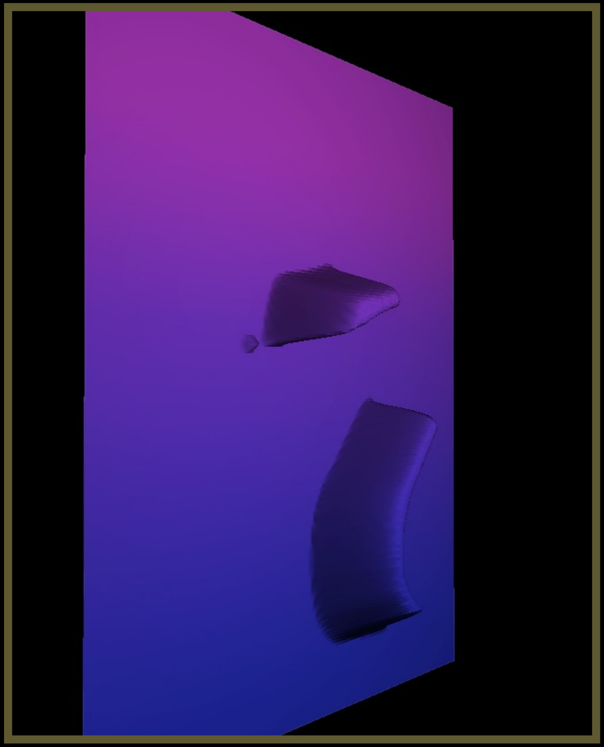
Arbitrary selection/segmentation restricts the affected pixels



Color channel



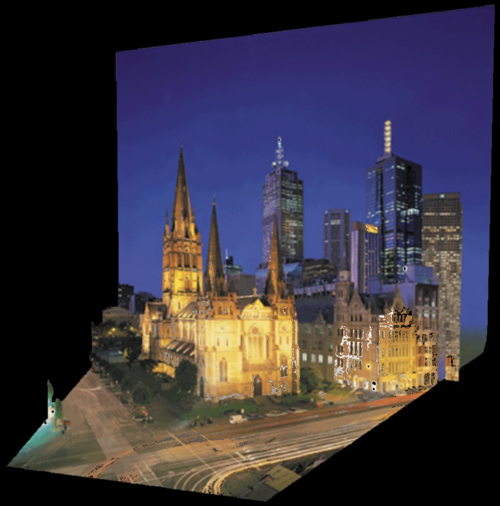
Depth channel



Side view

Going Beyond Painting

- Painting absolute depth is hard
- Hybrid geometric tools
  - But still pixel based (flexible, use of selection)
  - Geometry is temporary

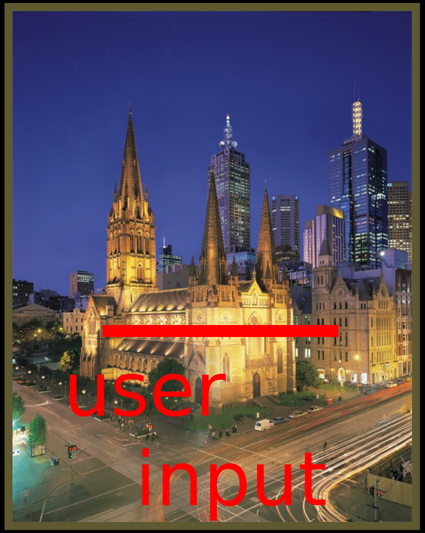


Update depth geometry

Ground Plane Tool

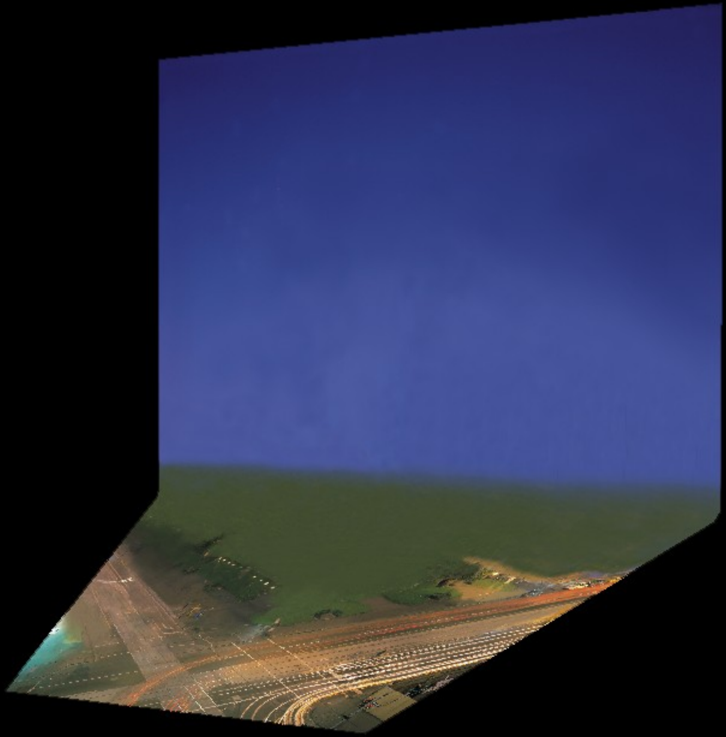
The ground plane is easy to infer (horizon)

Will be used as a referen



Reference view

Depth channel

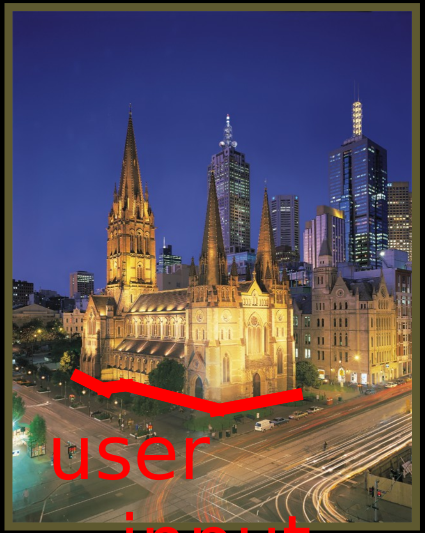


Side view

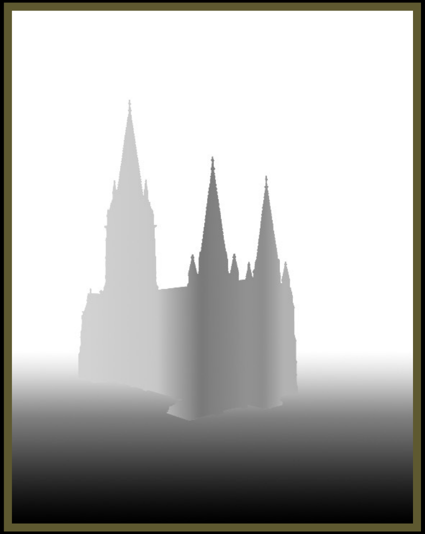
Vertical Tool

Uses ground plane as reference

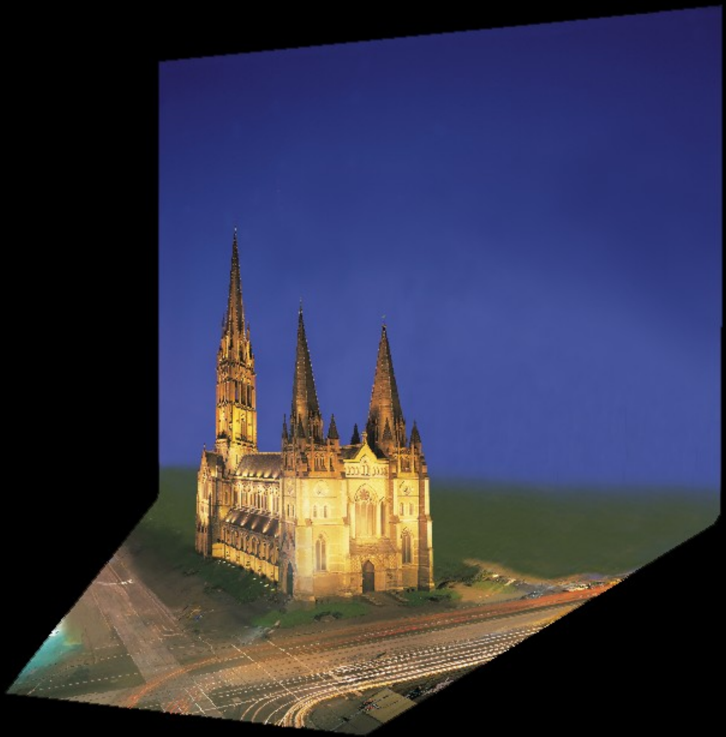
Draw contact between ground and object in image



Reference view



Depth channel

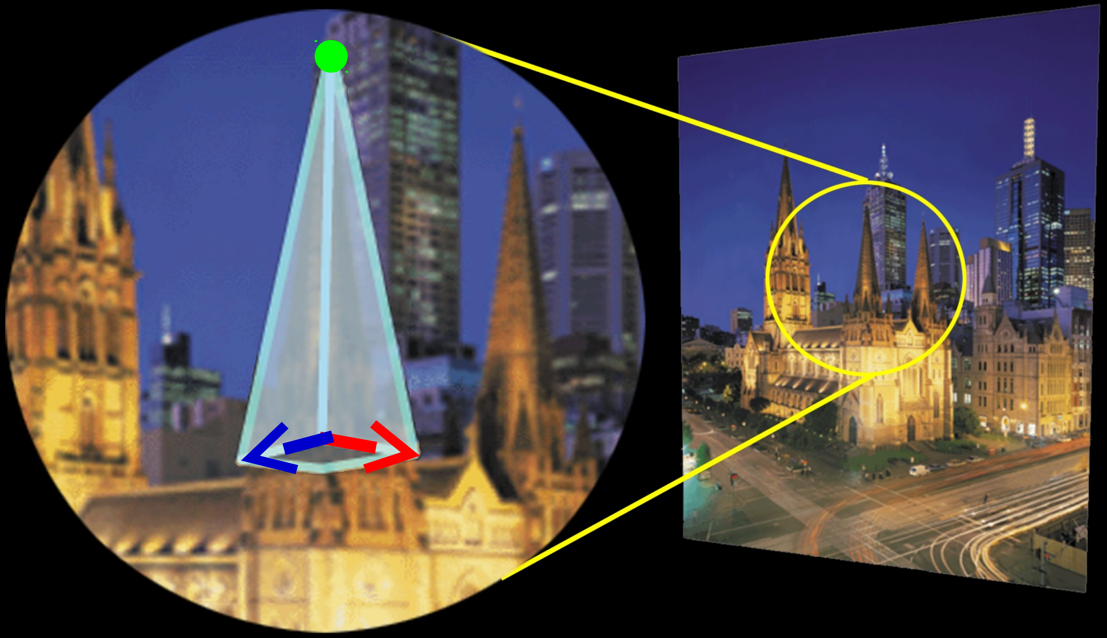


Side view

Geometric Primitives

Sphere, cylinder, box, pyramid, etc.

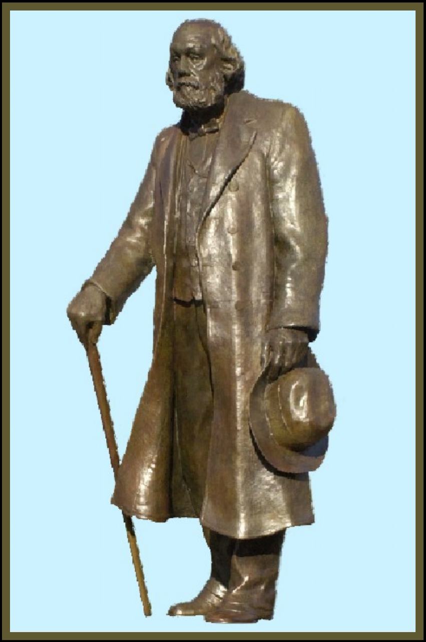
Possible snapping to constrain verticality



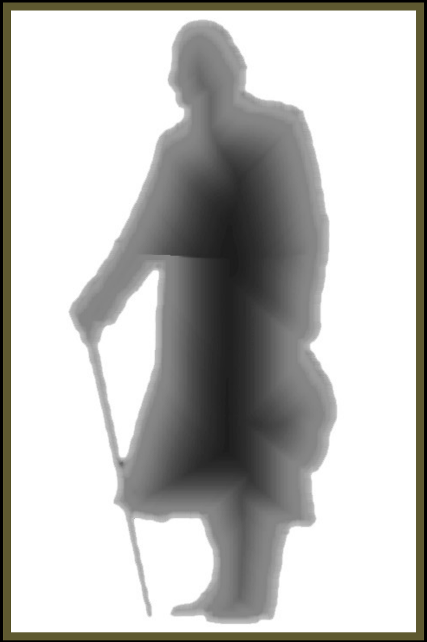
Organic Shapes

Level set method (Williams et al.98,Igarashi et al.99)

Distant depth at boundary, closer depth towards



Layer



Depth channel

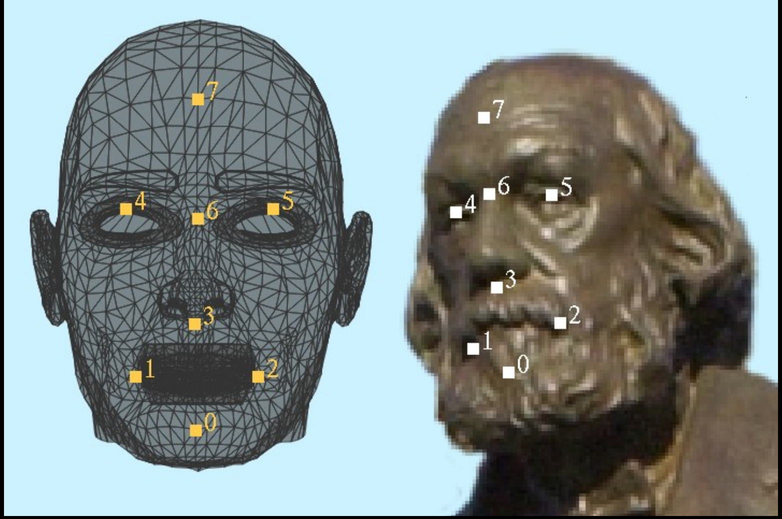
Generic Geometry Tool

3D template

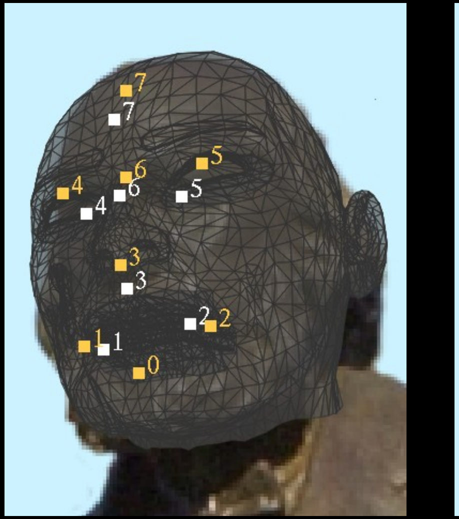
User defined point correspondences

3D pose optimization

Refinement through 2D morphing



User defined point correspondences



Optimized pose

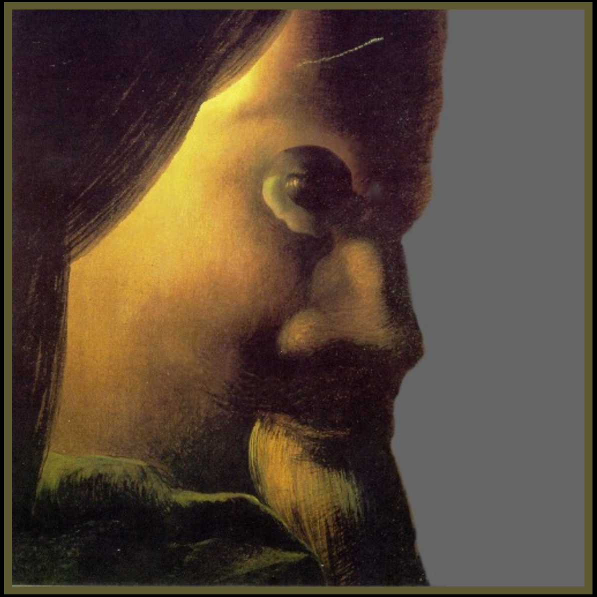
Side view

Depth Painting & Chiseling

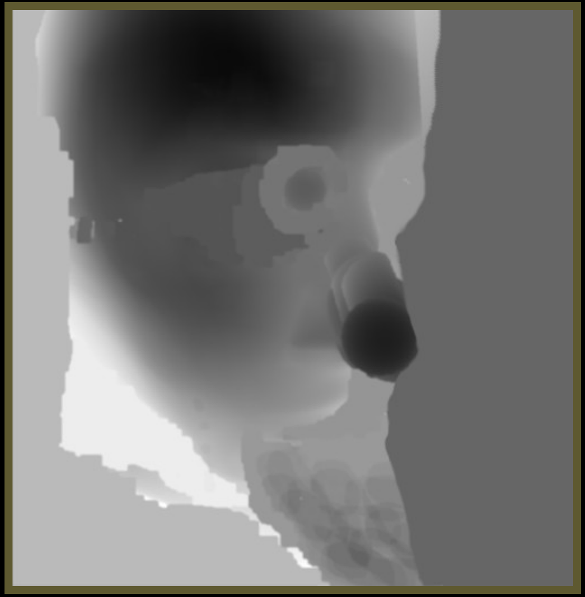
Paint on depth channel (Kang 98)

Relative or absolute

Local smoothing, sharpening

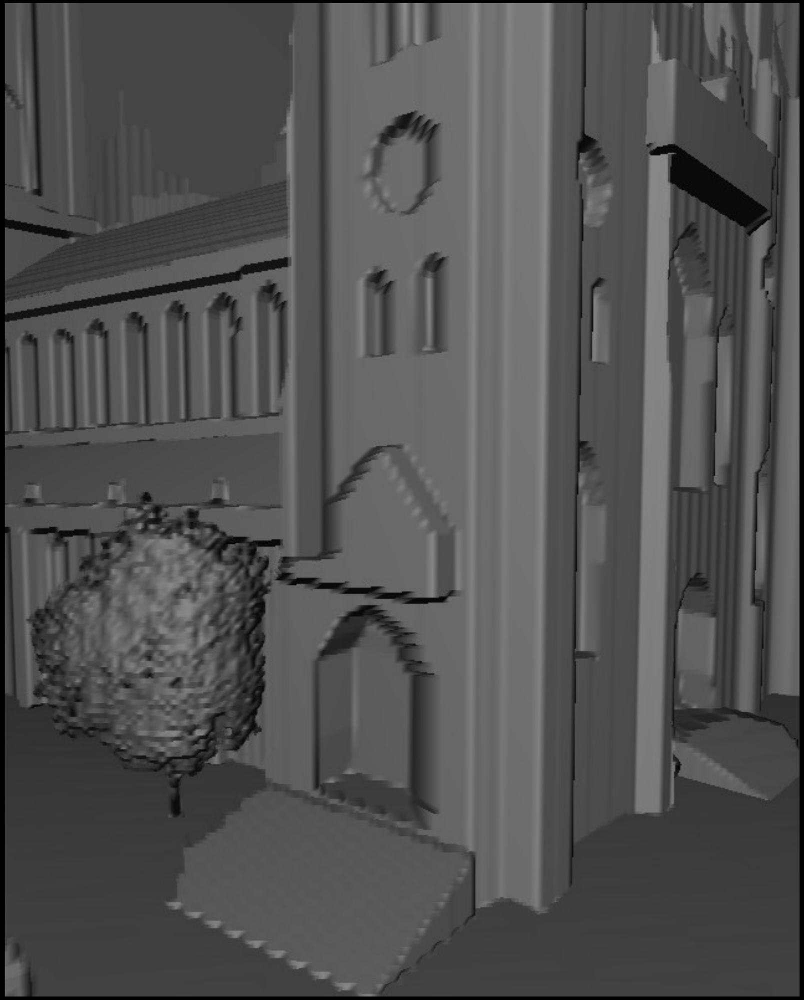


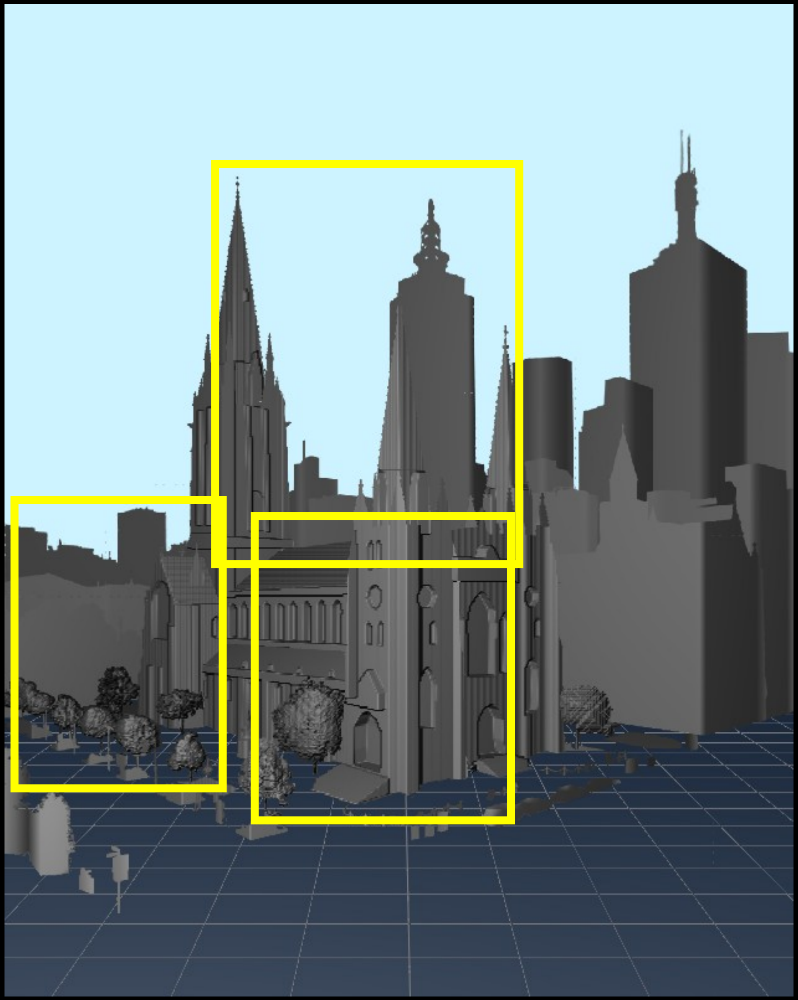
Layer



Depth channel

Refined Example





Refined depth

Outline

Image-based representation & user workflow

Depth assignment

Non-distorted clone brushing

Texture-illuminance decoupling

2D Clone Brush

Copies via brush interface

2D Clone Brush

- Copies via brush interface

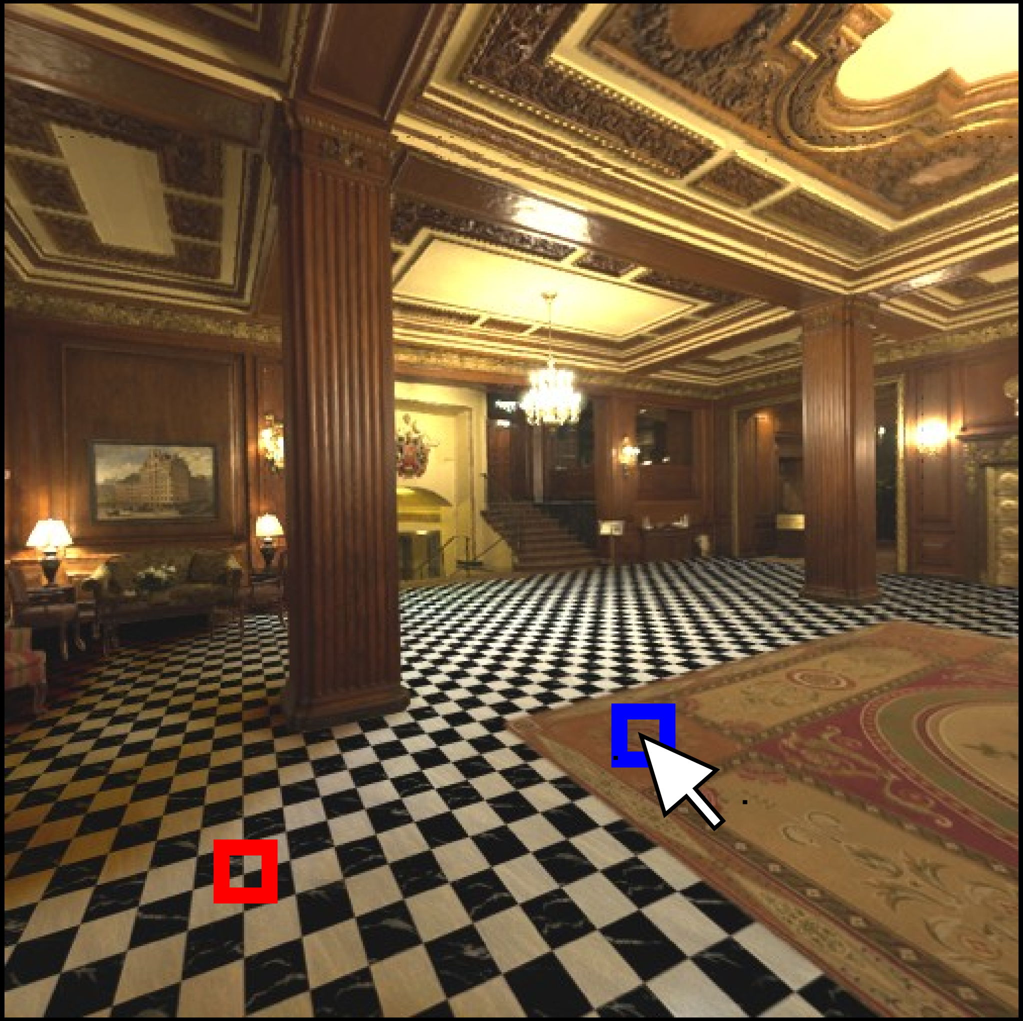
□ source pixel

2D Clone Brush

Copies via brush interface

🟥 source pixel

🟦 destination pixel

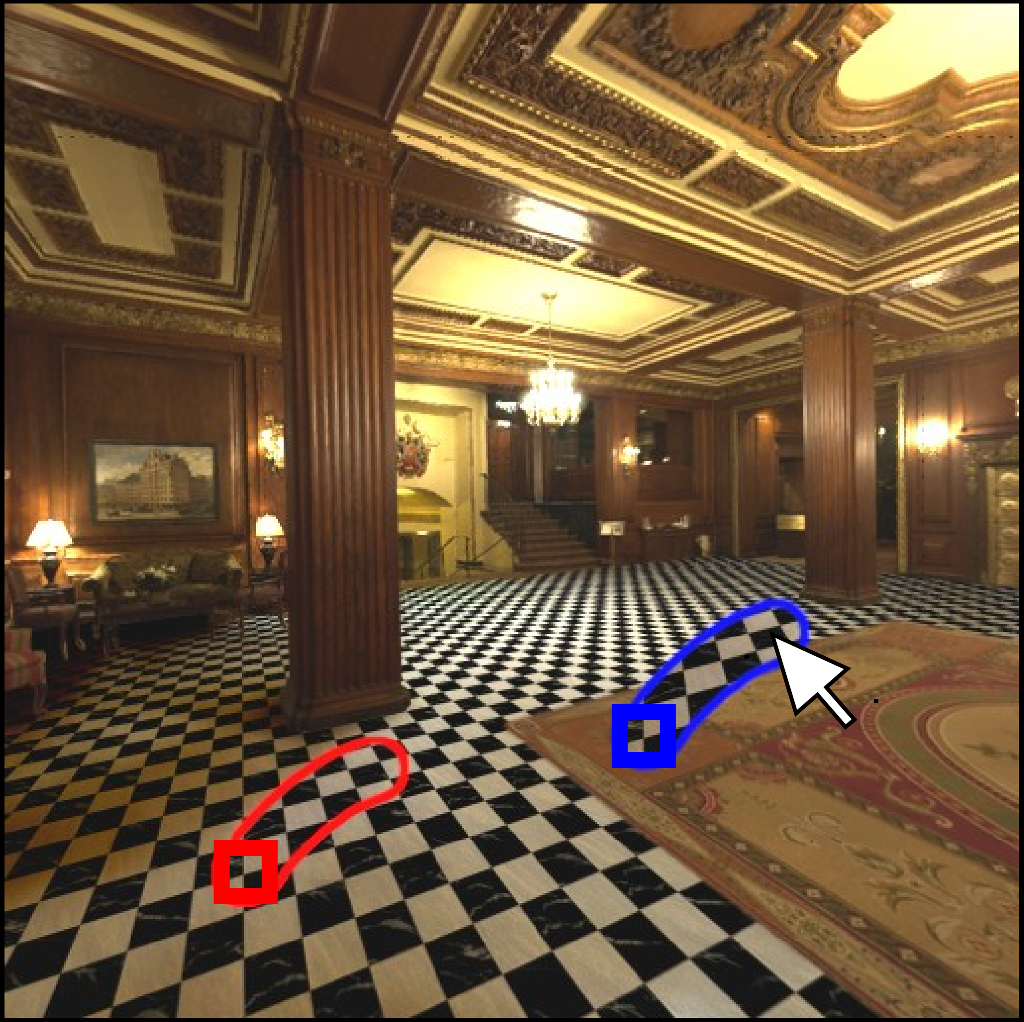


2D Clone Brush

Copies via brush interface

□ source pixel

□ destination pixel

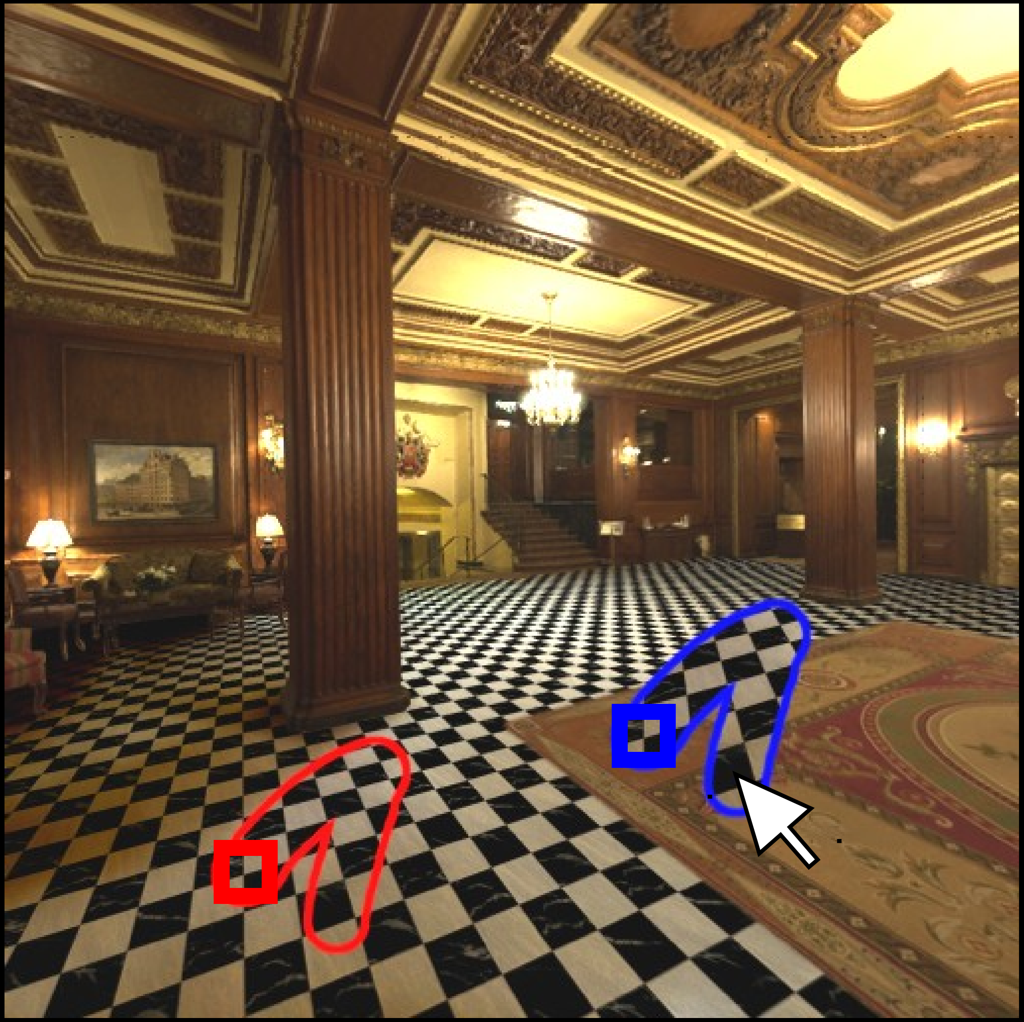


2D Clone Brush

Copies via brush interface

□ source pixel

□ destination pixel

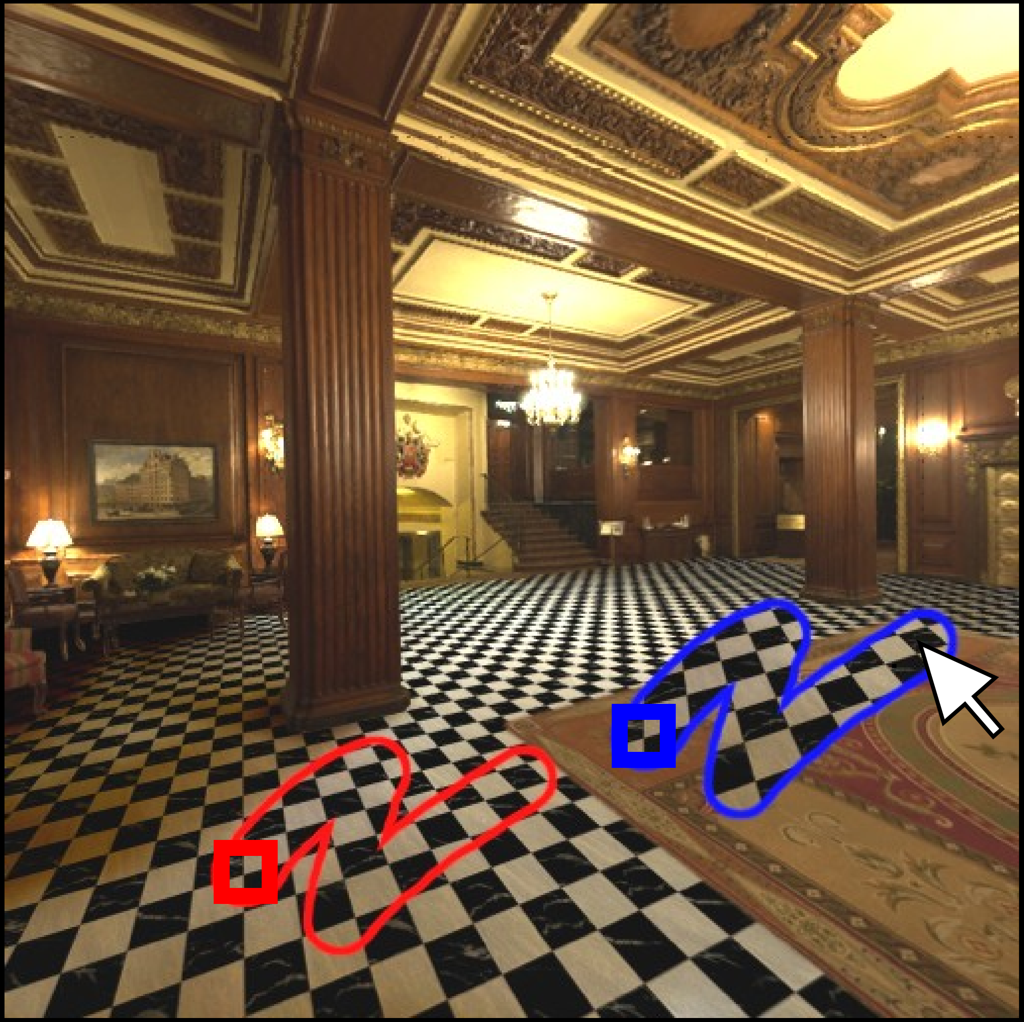


2D Clone Brush

Copies via brush interface

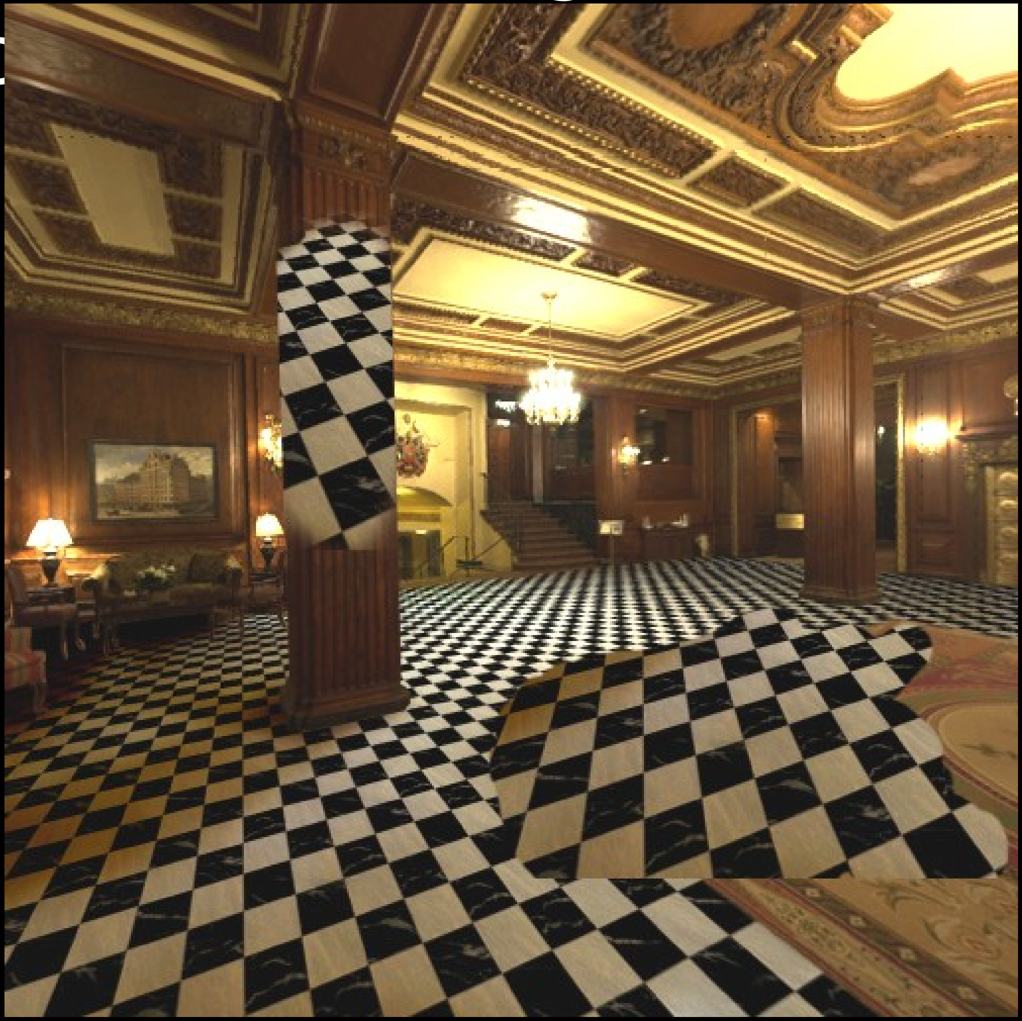
🟥 source pixel

🟦 destination pixel



Limitations of 2D Clone Brushing

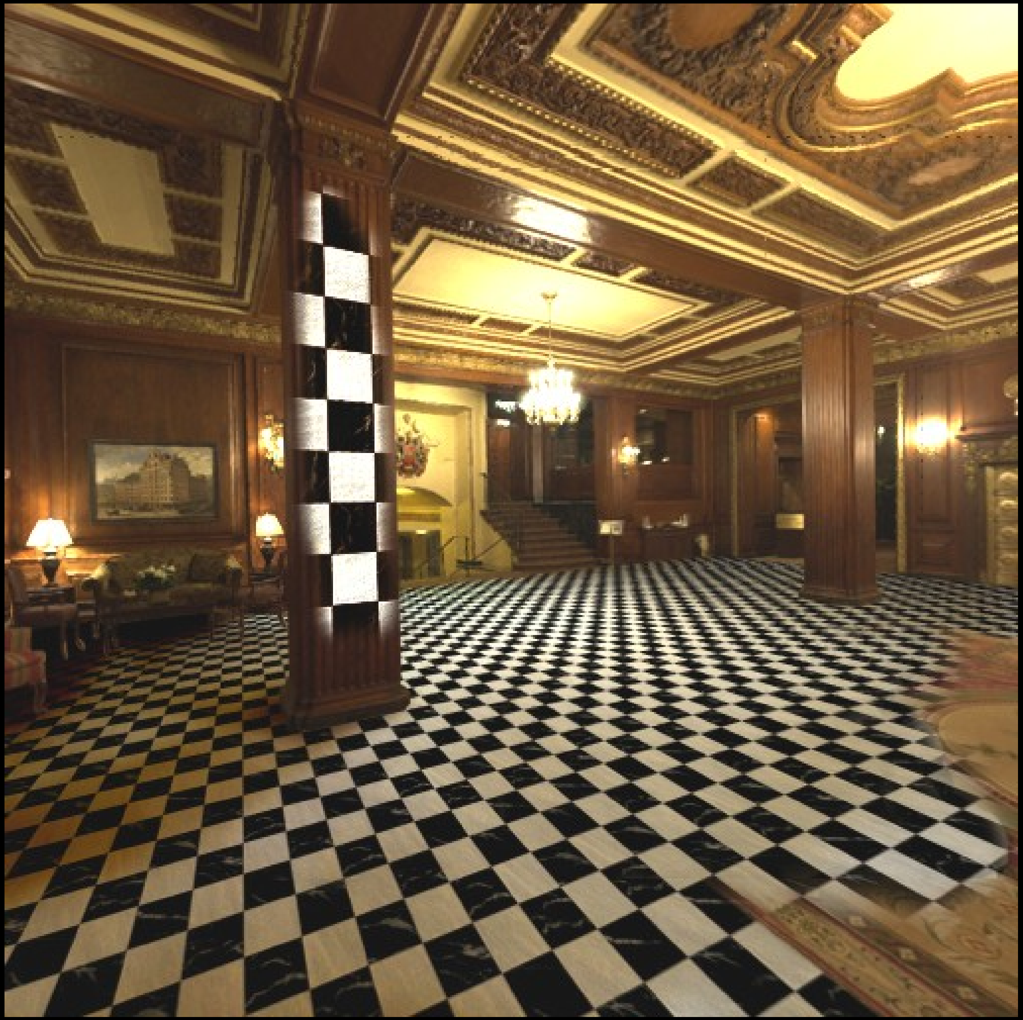
Distortions due to foreshortening and surface orientatio



Goal

Cope with

- Foreshortening
- Surface orientatio



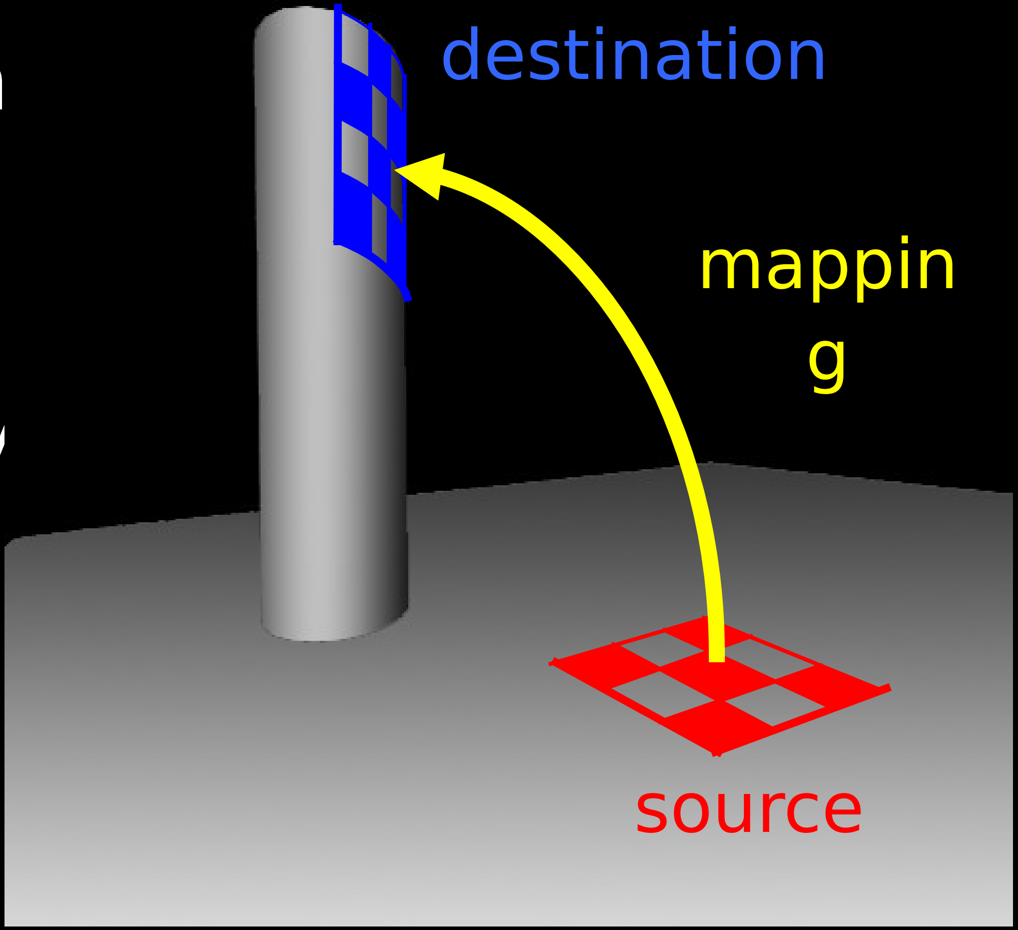
Coping with Distortions

Determine a mapping between pixels of source & destinat

Minimize distortion

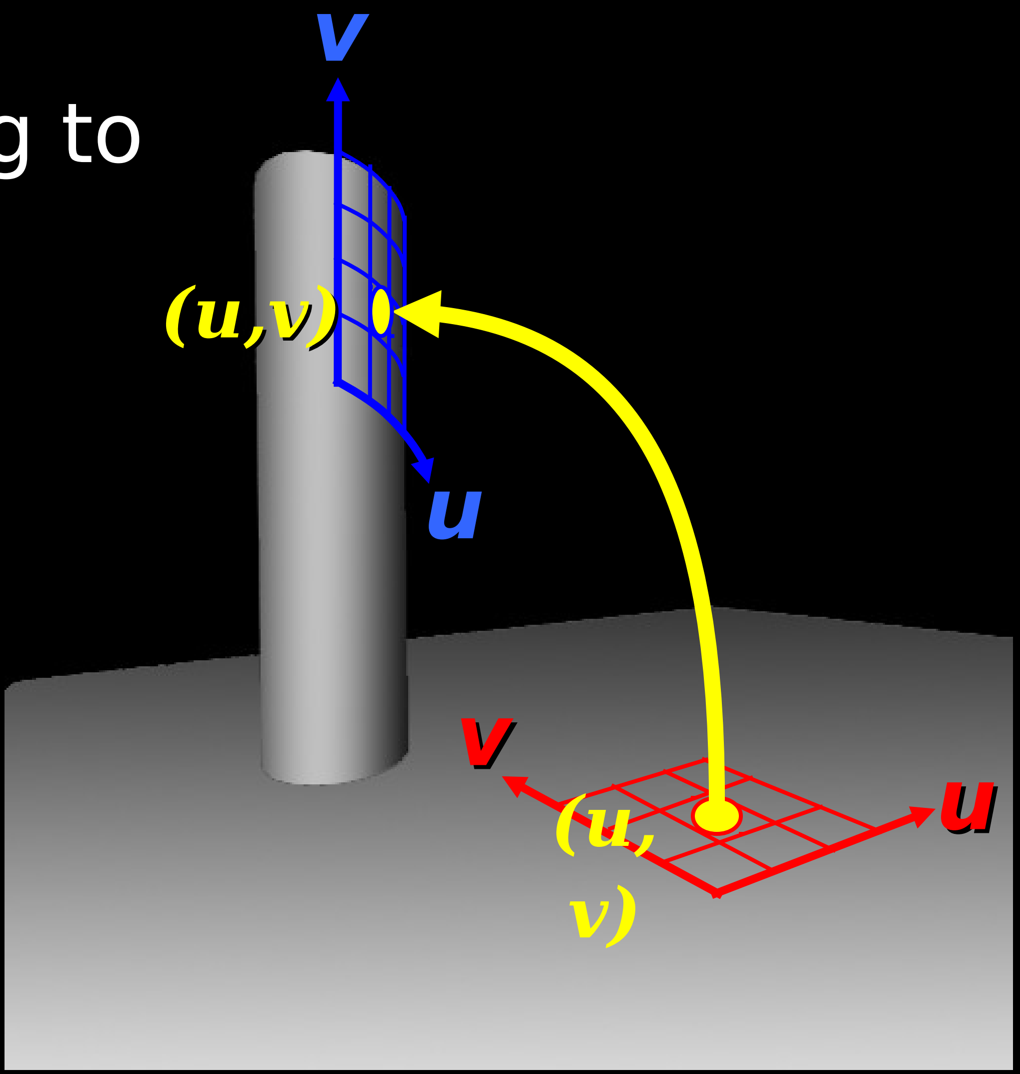
- Foreshortening
- Surface orientatio

Arbitrary geometry



Parameterization

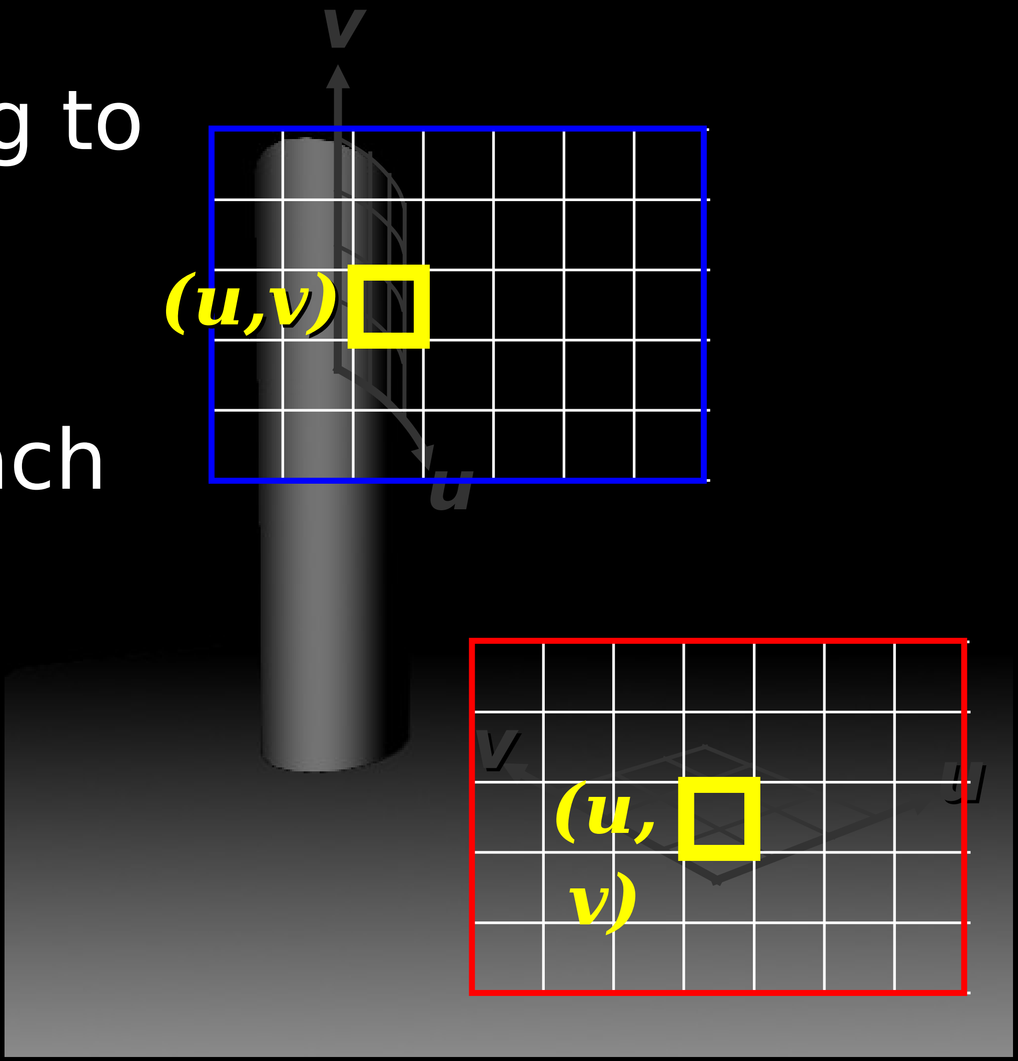
Map UV conforming to geometry



Parameterization

Map UV conforming to geometry

Compute UV for each pixel



Parameterization Optimization

Lévy & Mallet (1998)

- Iterative optimization
- Minimizing angular and iso-line distortion

Differences

- Real time
- No boundary conditions

Extensions to Lévy & Mallet's Work

Expanding *active region*

Optimization proceeds as user clone-brushes

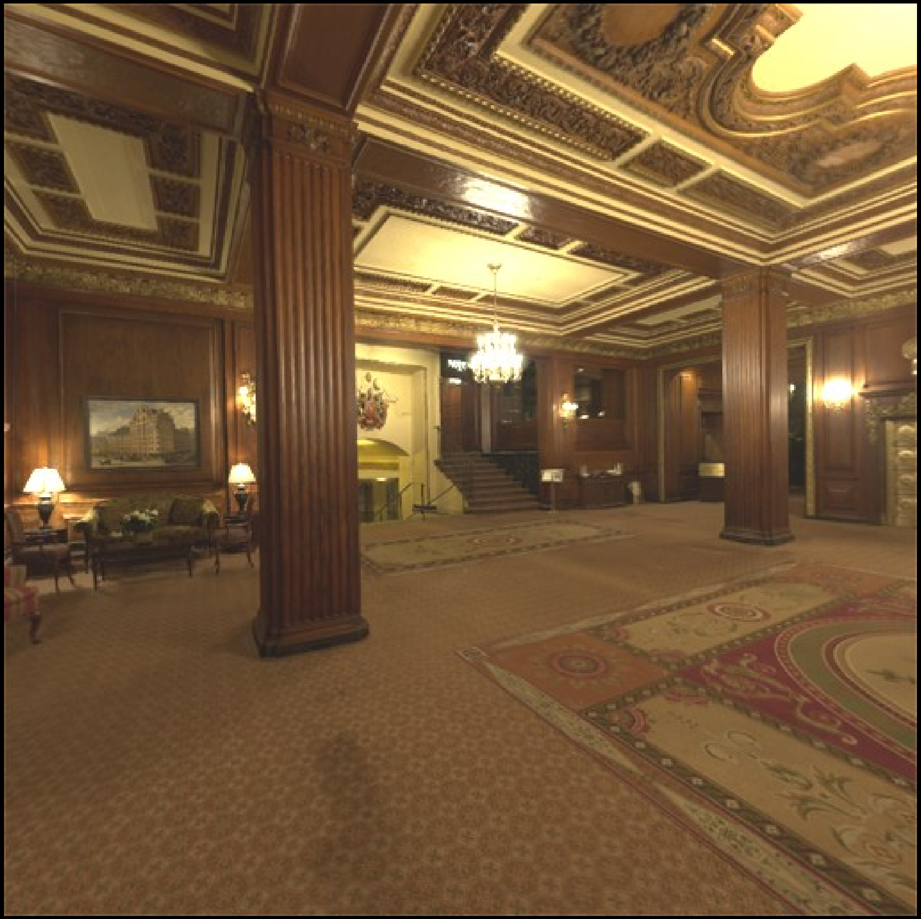
Freeze parameters of brushed pixels

Acceleration

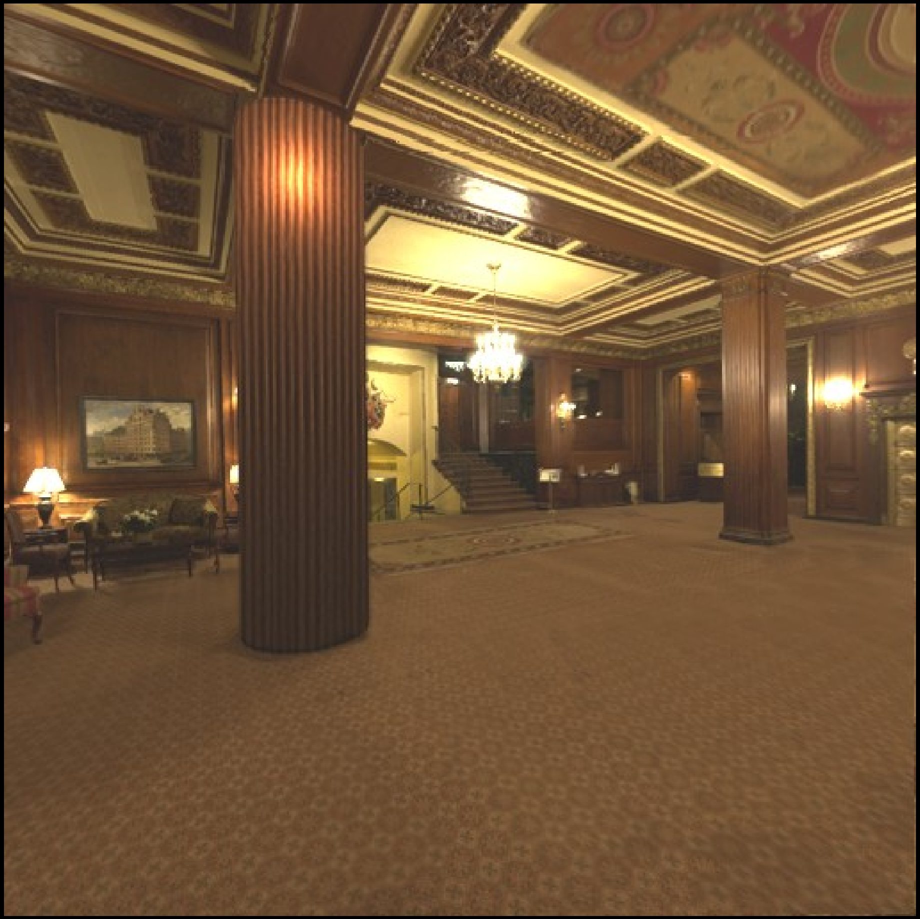
- Sub-sampling
- Smart UV initialization

Parameterization Visualization

Examples



Initial image



Clone brushed image

Examples

Outline

Image-based representation & user workflow

Depth assignment

Non-distorted clone brushing

Texture-illuminance decoupling

Motivation

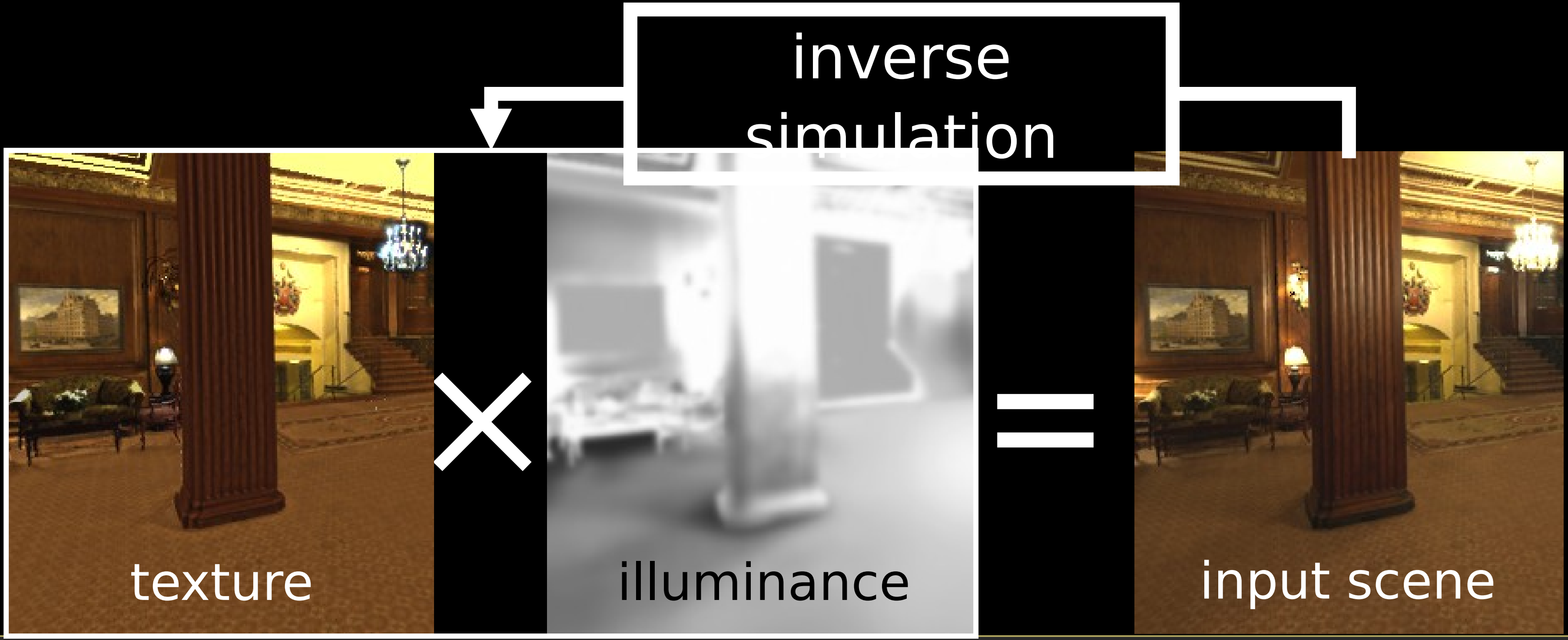
Changing materials

Relighting

Inverse Lighting Simulation

Physically-based approaches

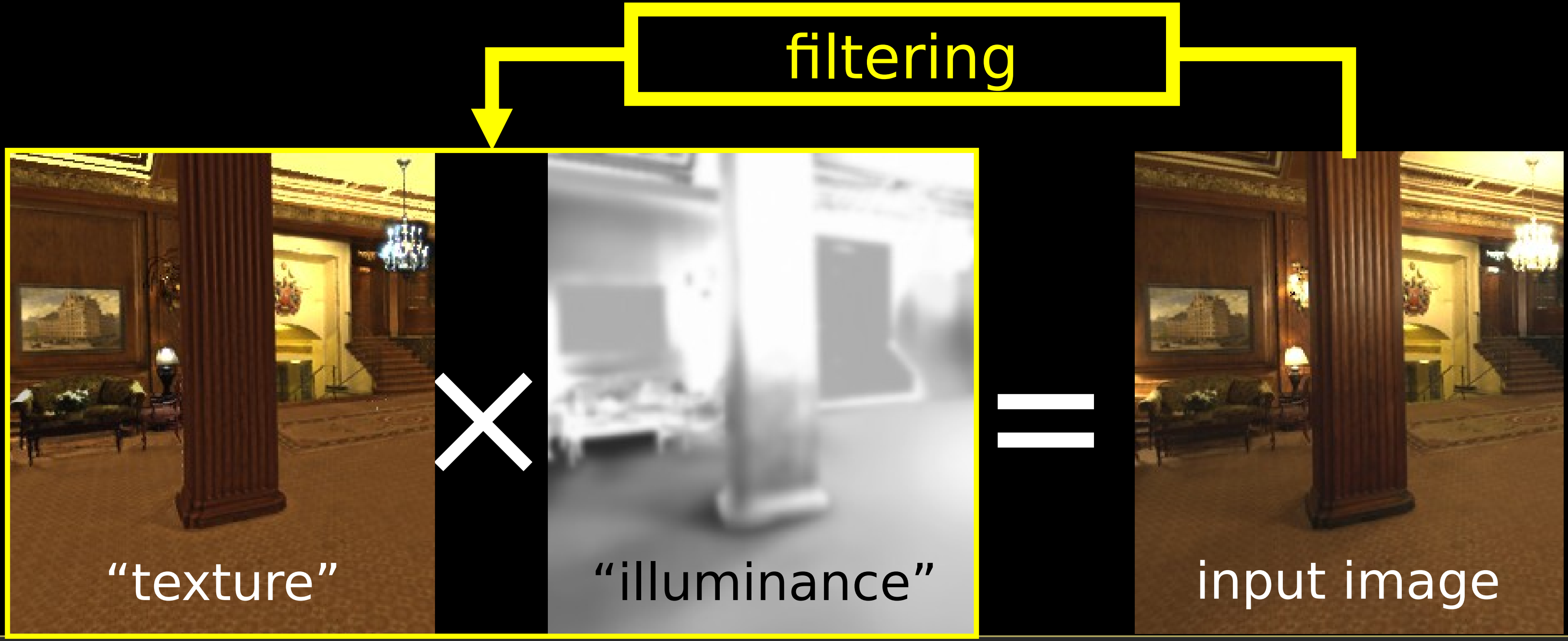
Fournier et al.93, Drettakis et al.97, Debevec.98, Yu et al.99, Loscos et al.99, Loscos et al.00



Texture-Illuminance Decoupling

Not physically based

- Our “texture” and “illuminance” are reasonable estimates

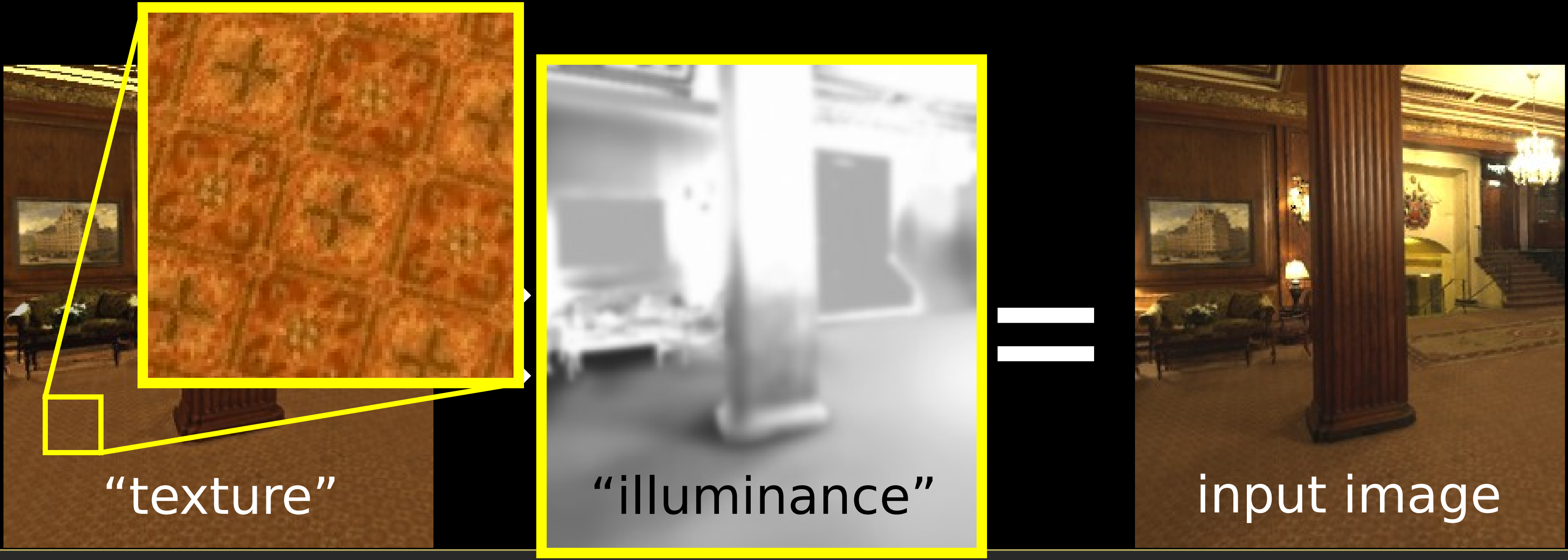


Texture-Illuminance Decoupling

Not physically based

Assumptions:

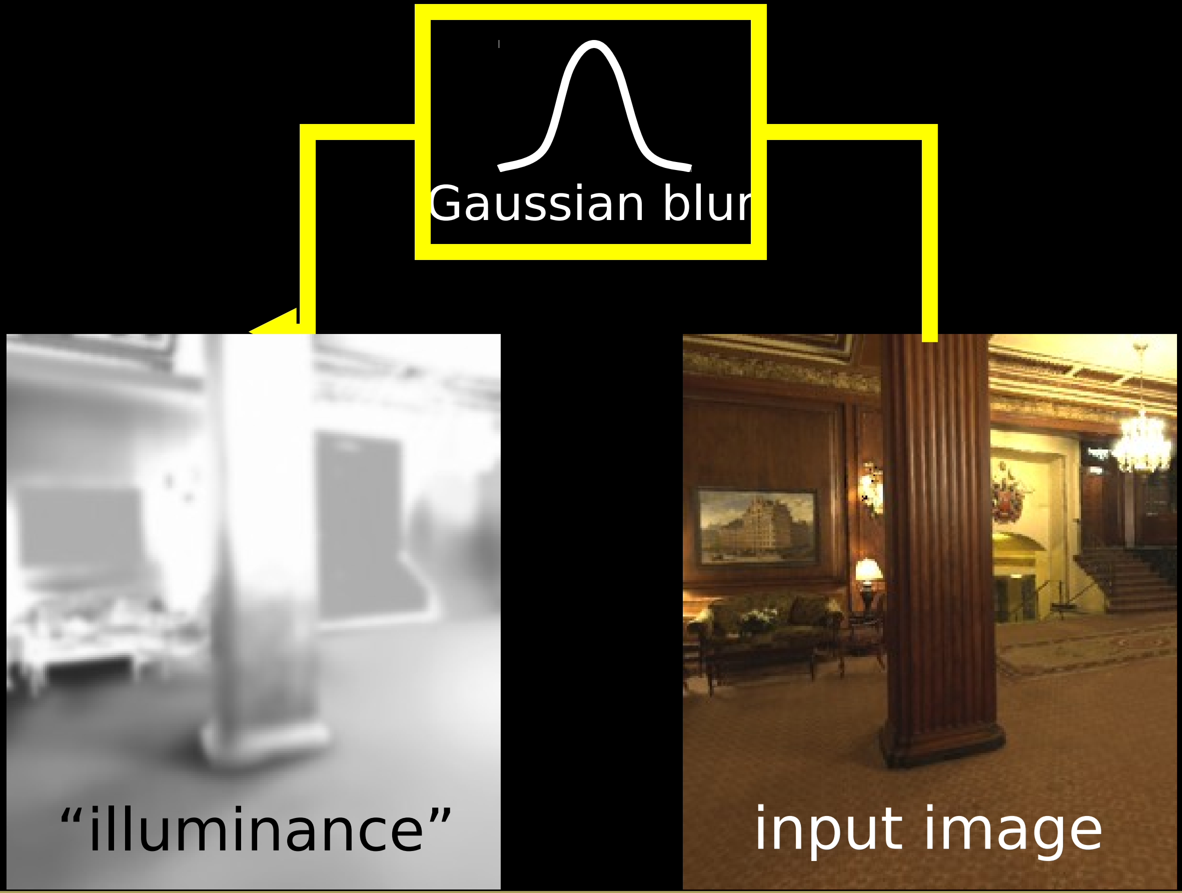
- Small-scale features → “texture”
- Large-scale features → “illuminance”



General Idea: A Naïve Approach

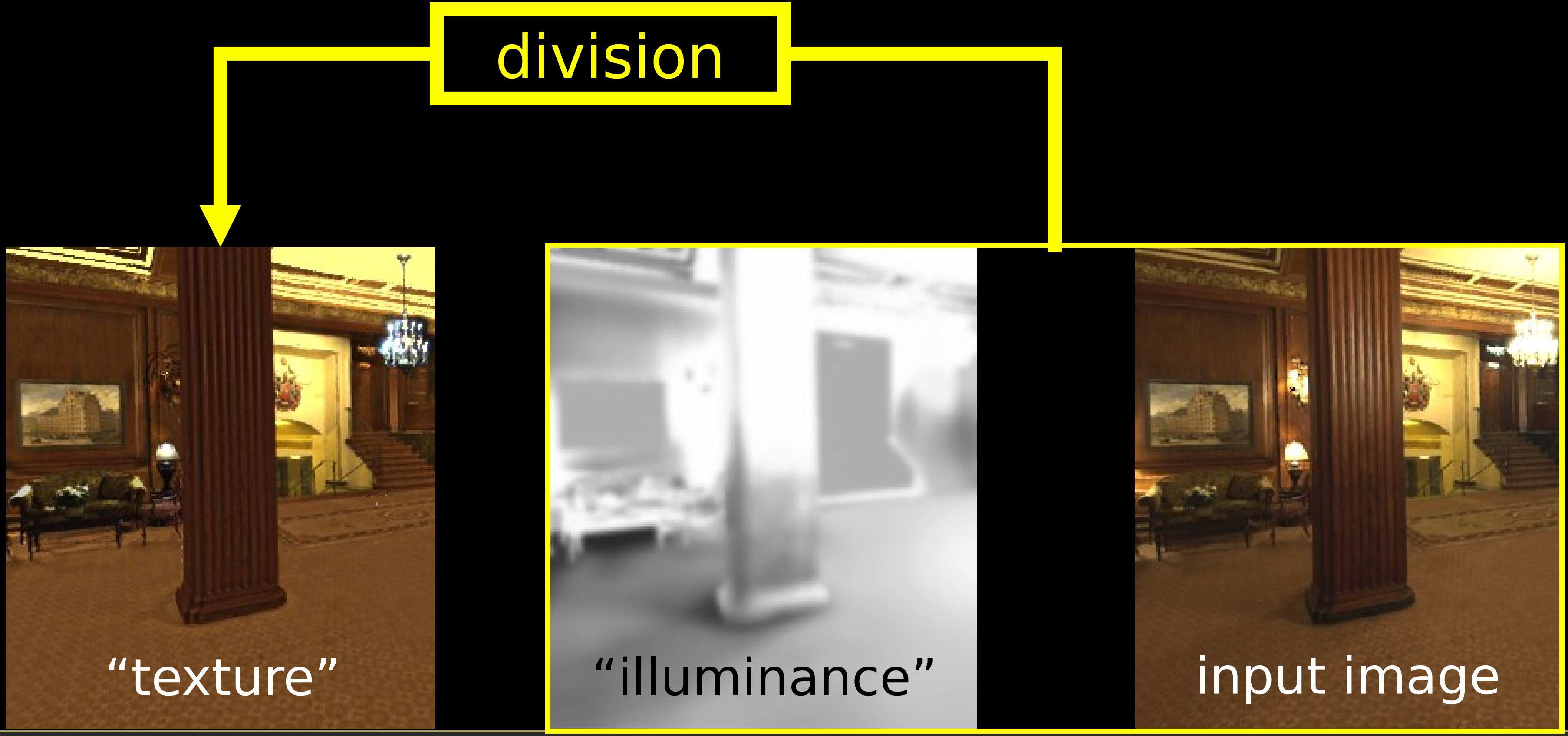
Large-scale features using low-pass filter

- Color is assumed to be from texture

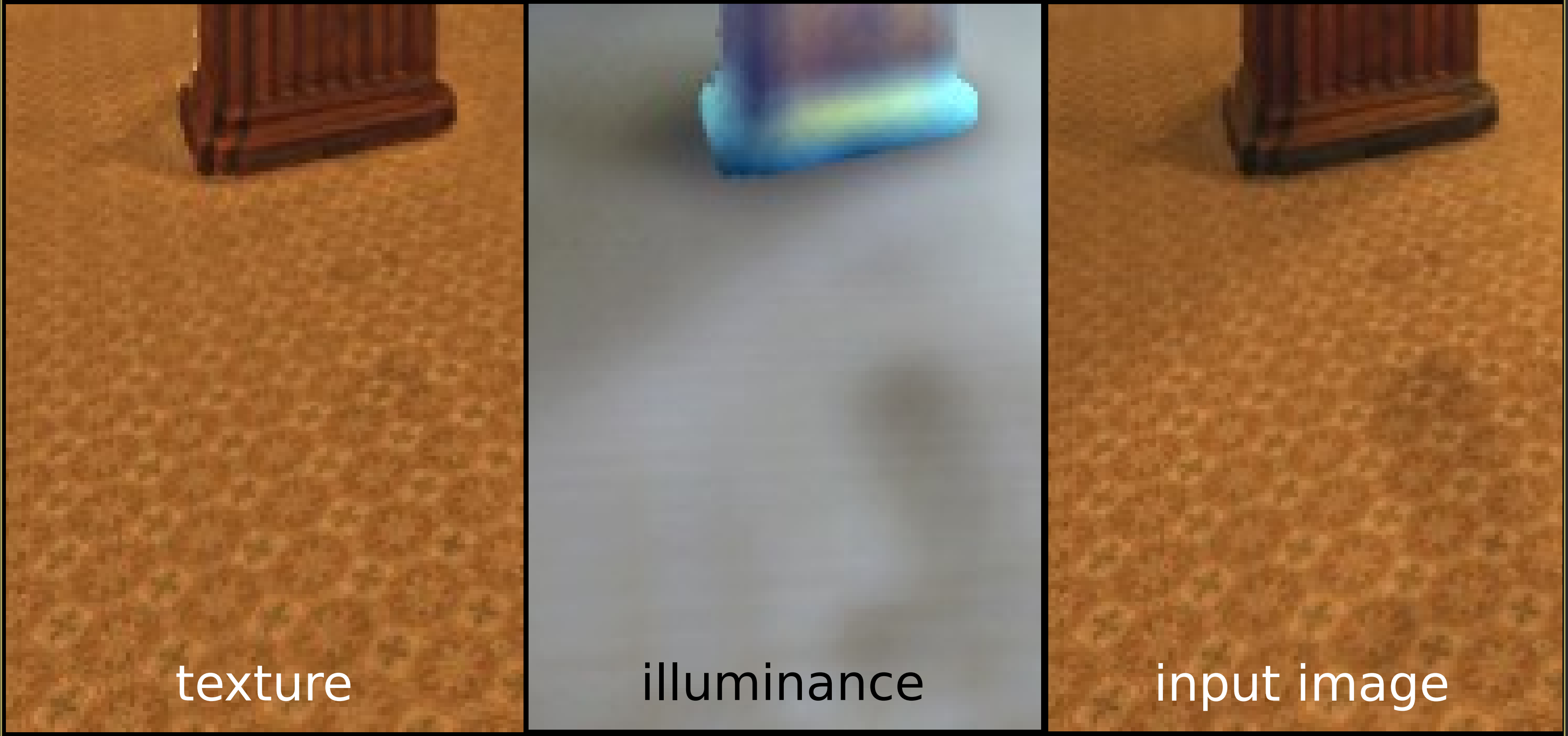


General Idea: A Naïve Approach

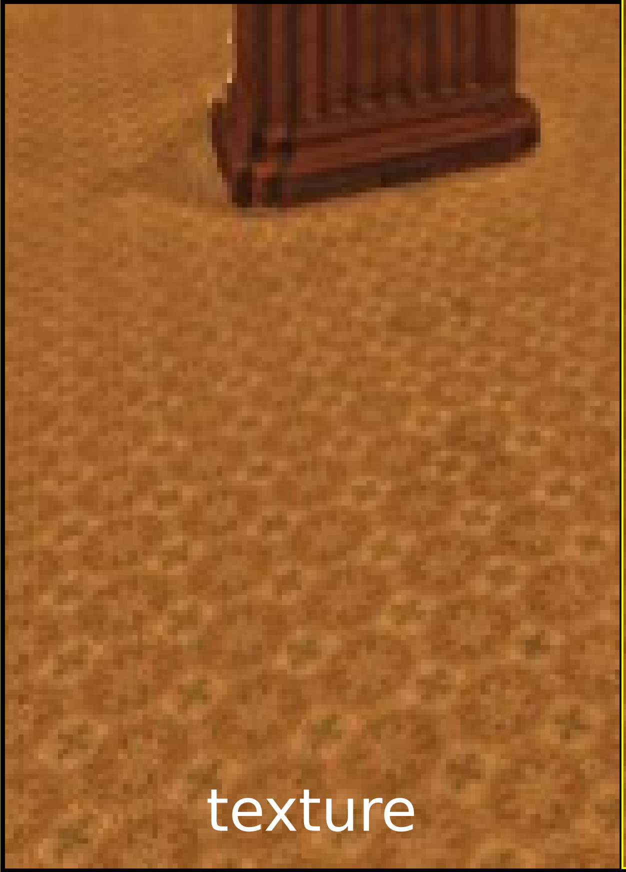
Extract texture from illuminance and input image

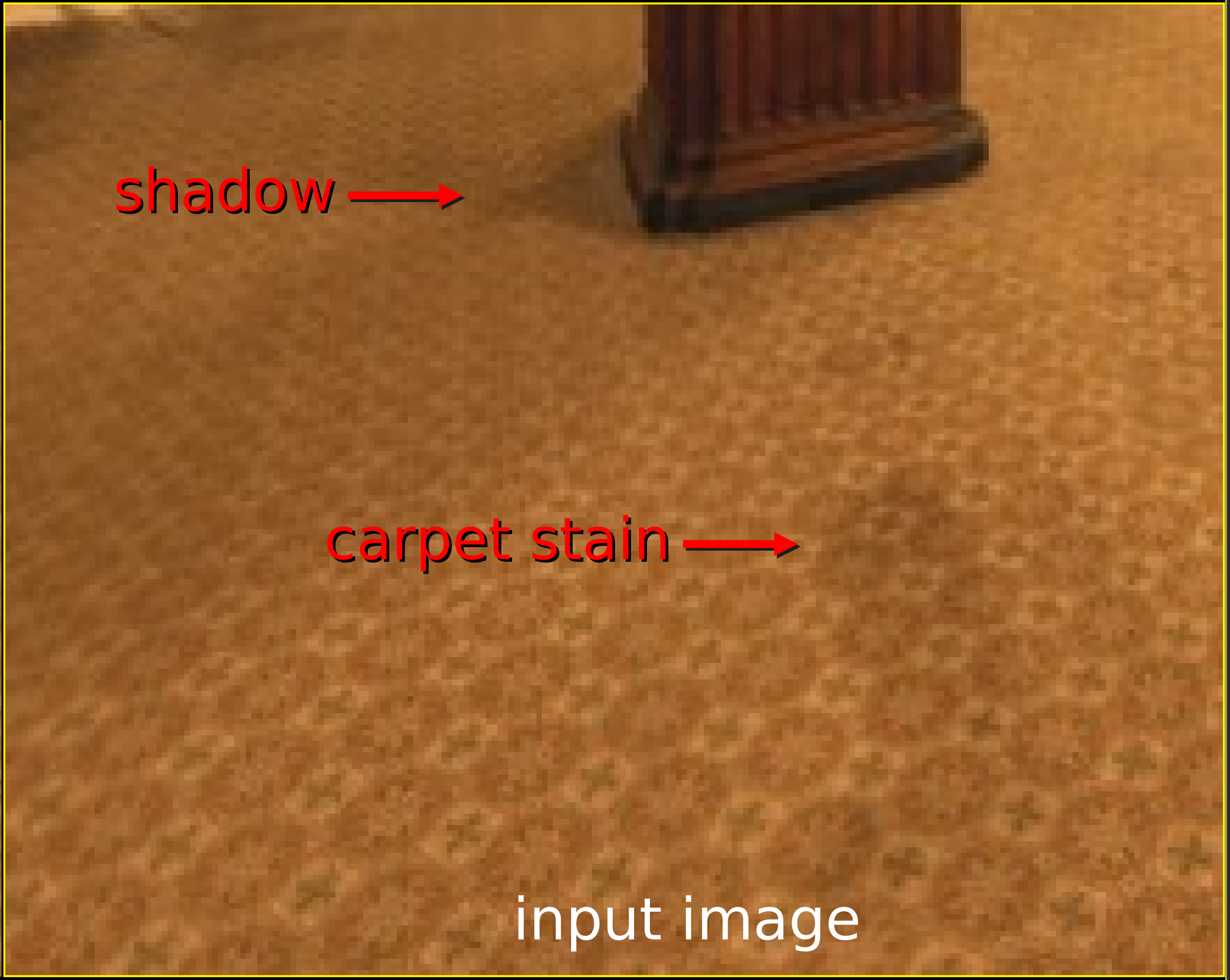


Problems with the Naïve Approach

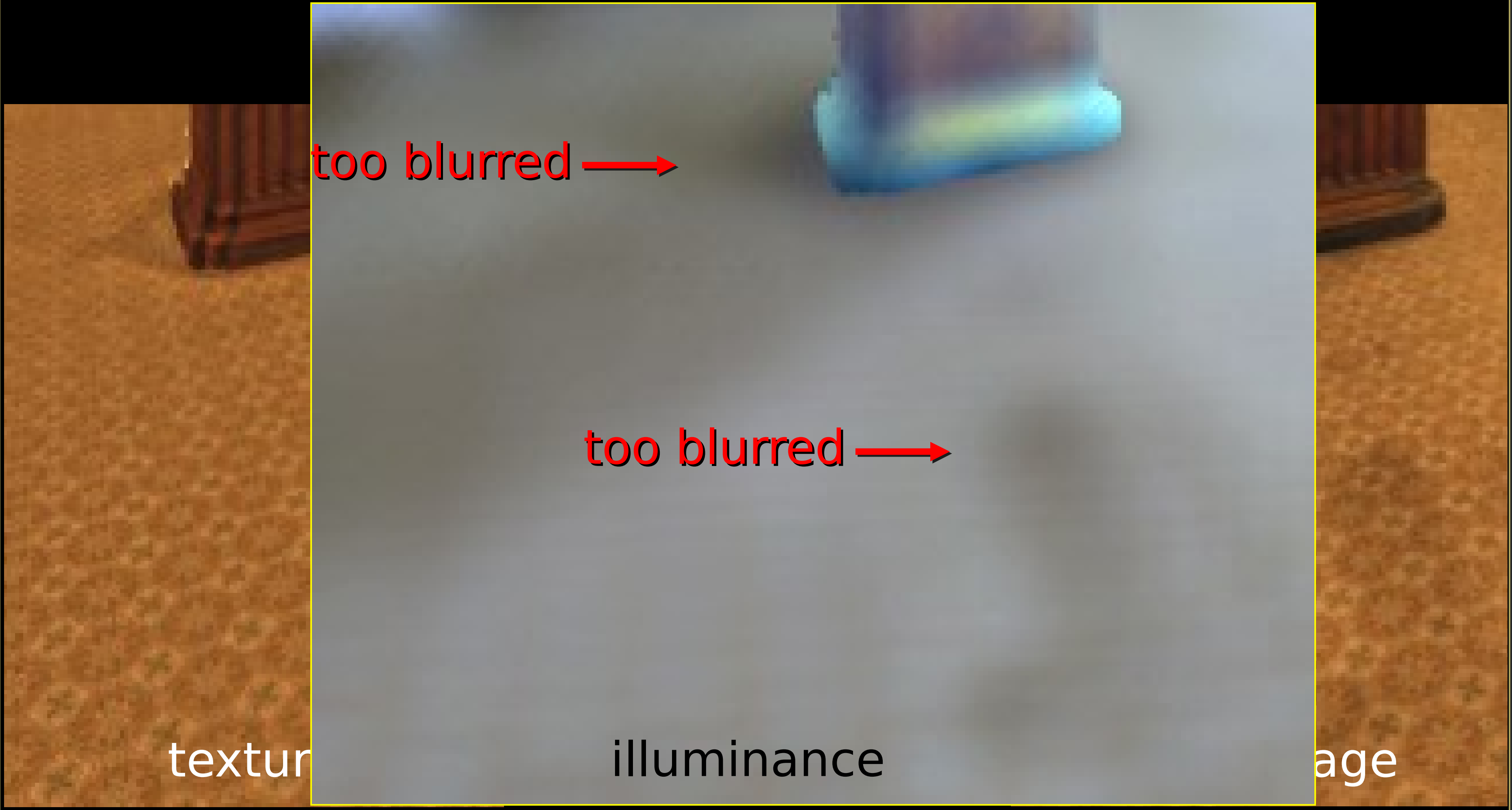


Problems with the Naïve Approach

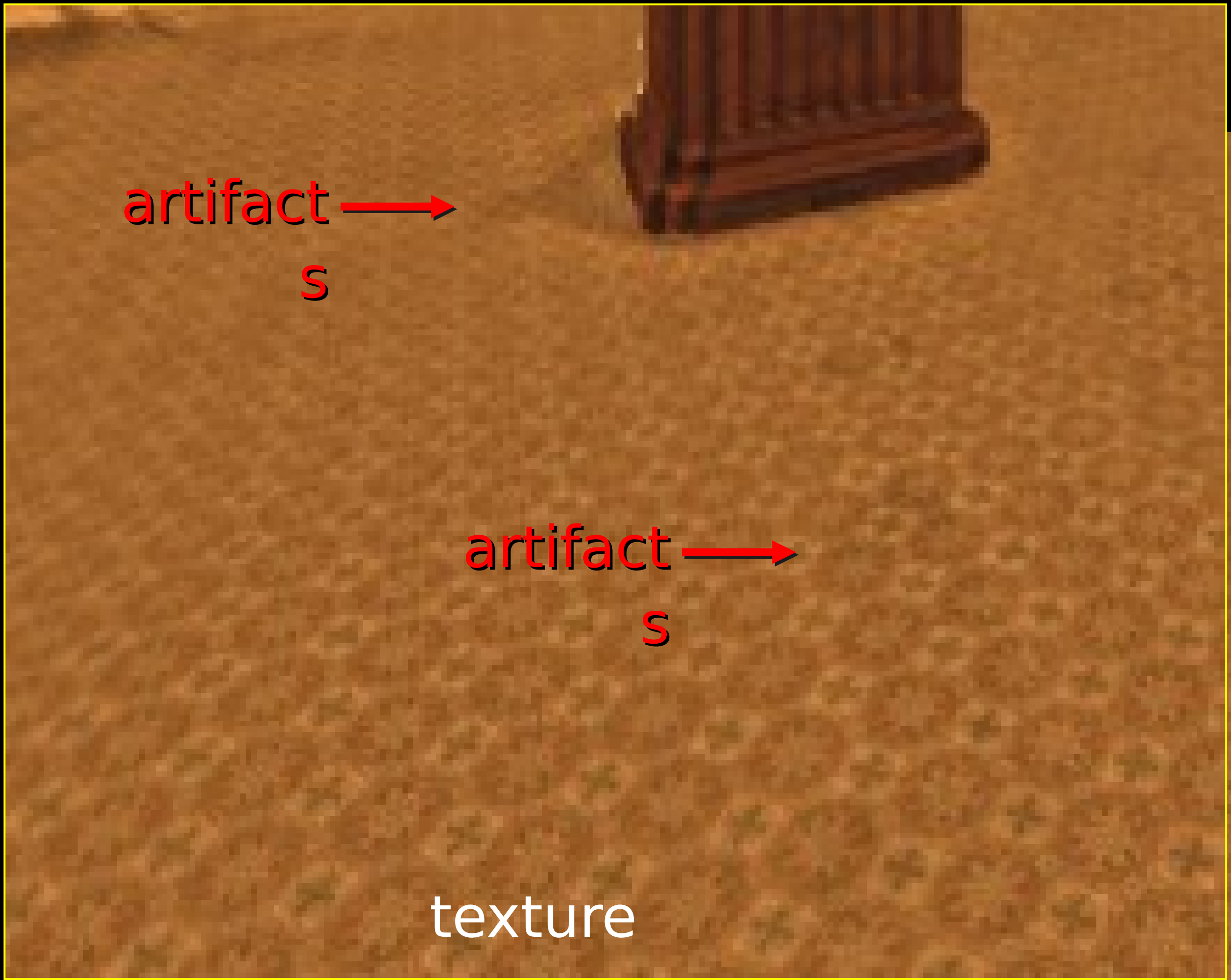




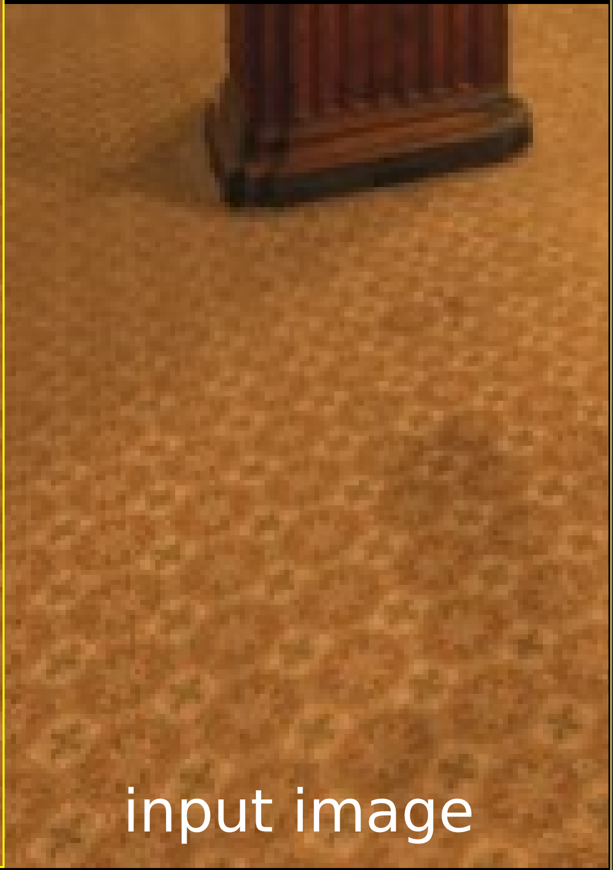
Problems with the Naïve Approach



Problems with the Naïve Approach



texture

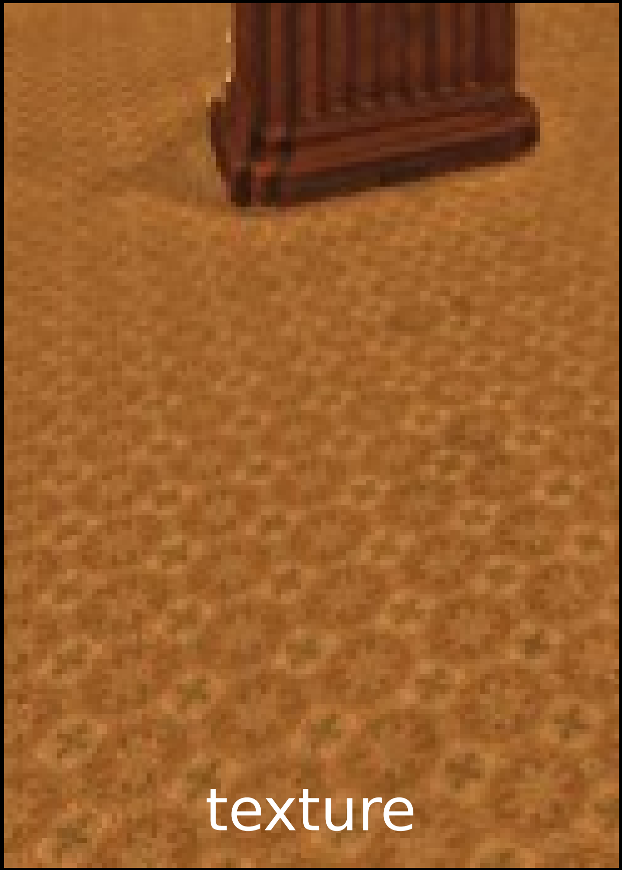


input image

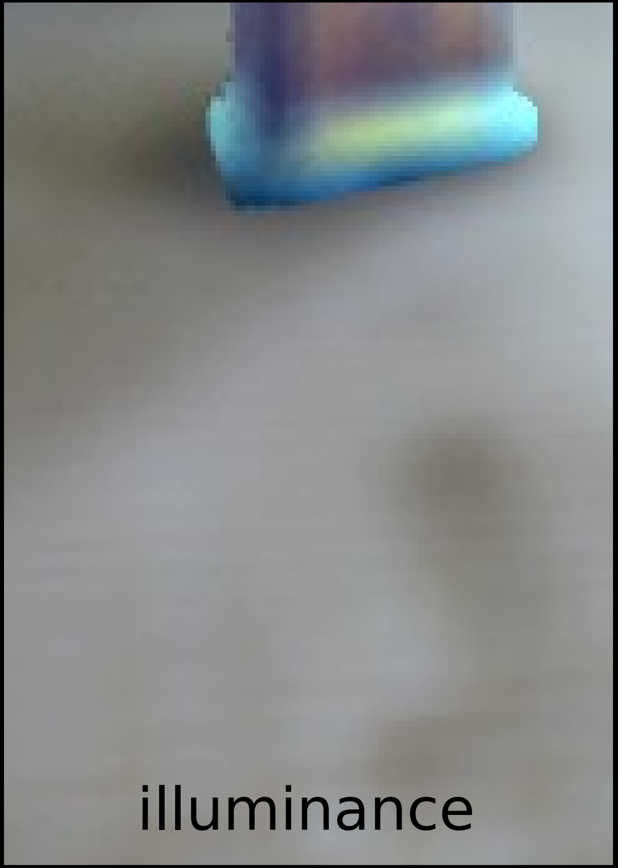
Problems with the Naïve Approach

Failure due to texture foreshortening

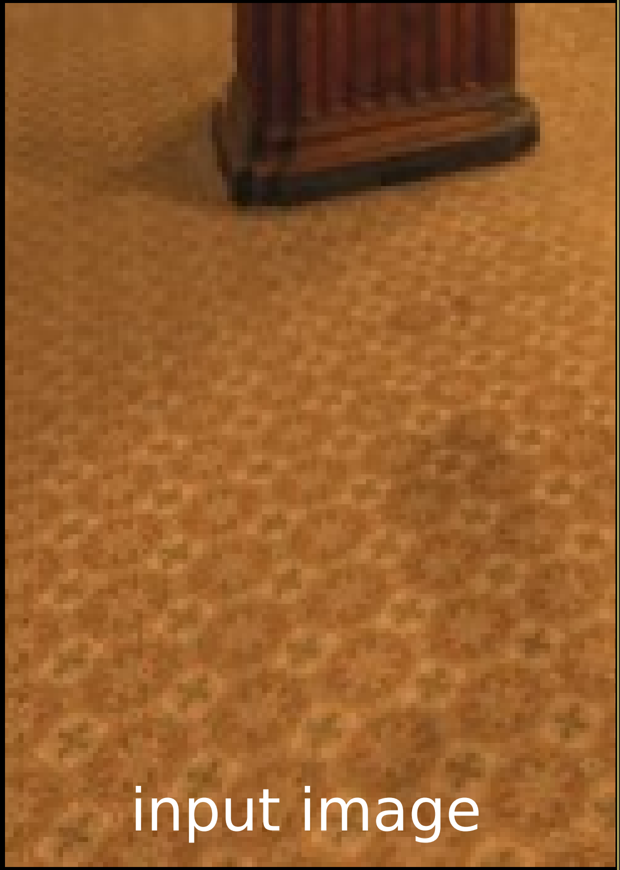
Artifacts at shadow boundaries



texture



illuminance

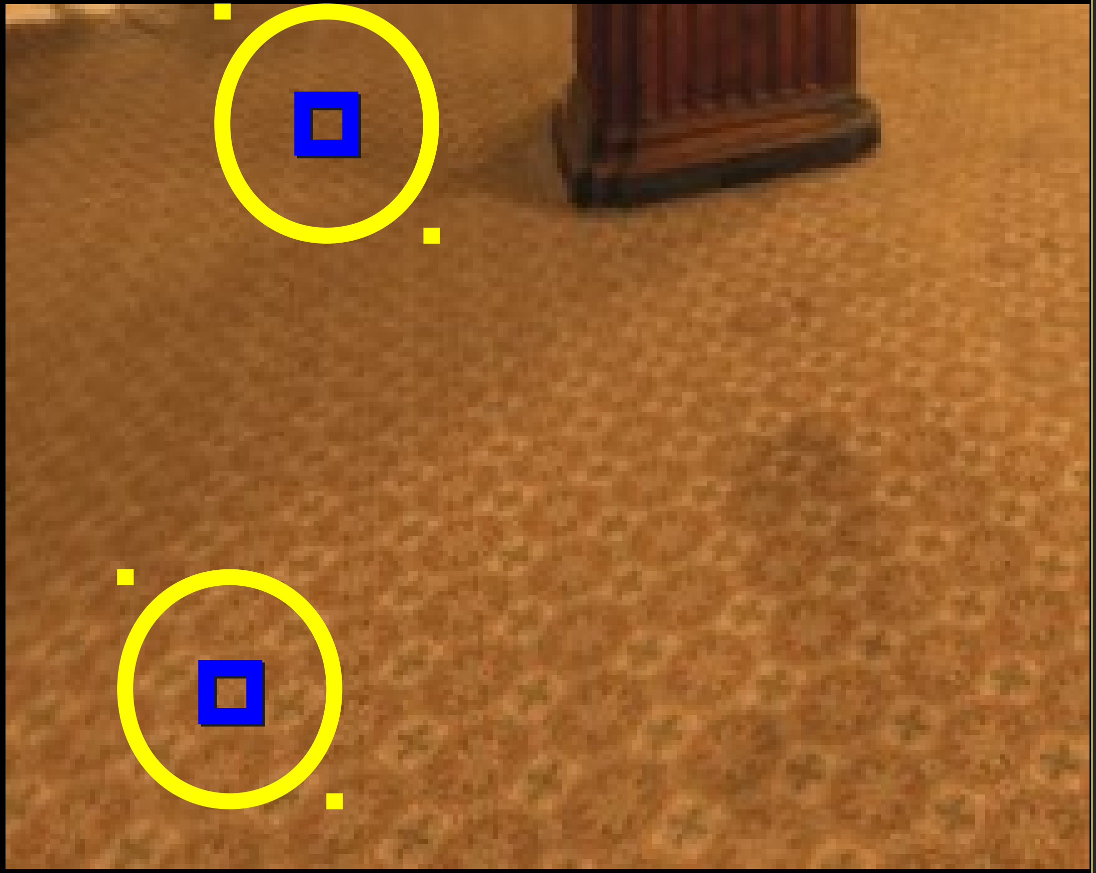


input image

Treatment of Foreshortening

□ pixel

○ kernel size

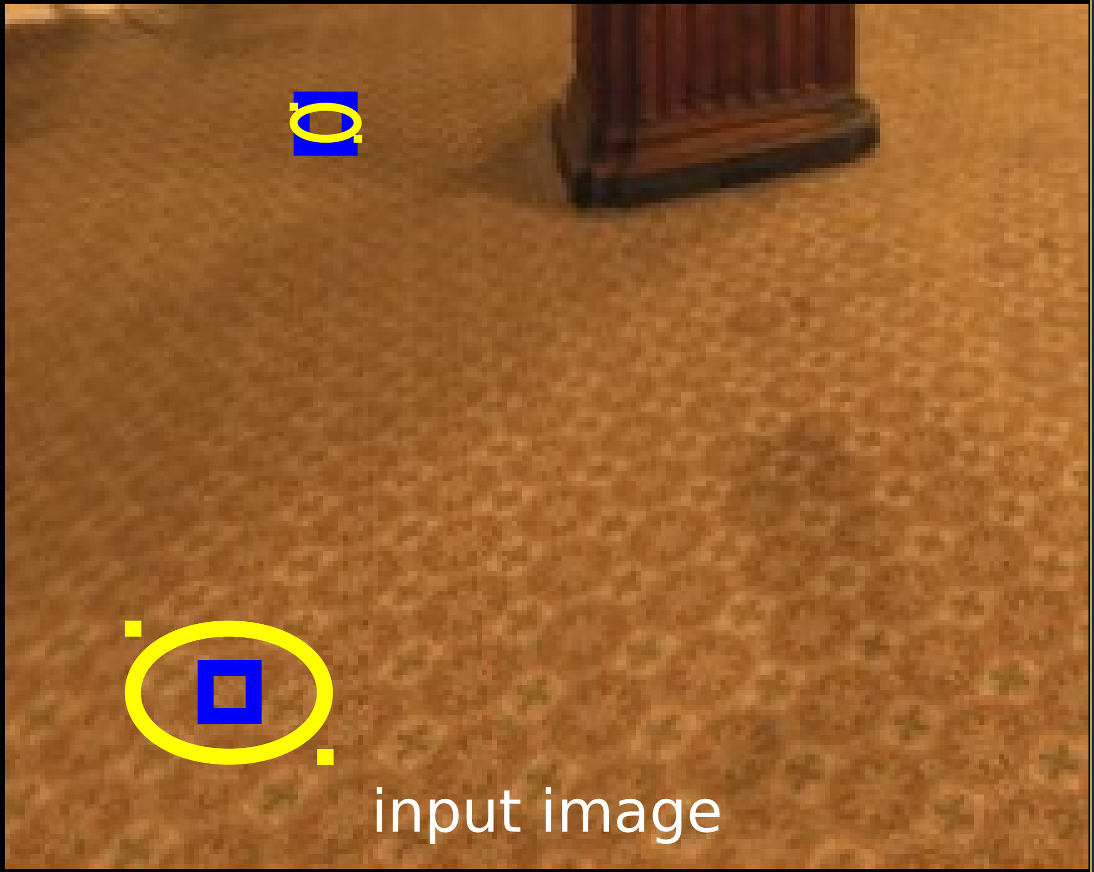


Treatment of Foreshortening

Blurring depends on distance and orientation

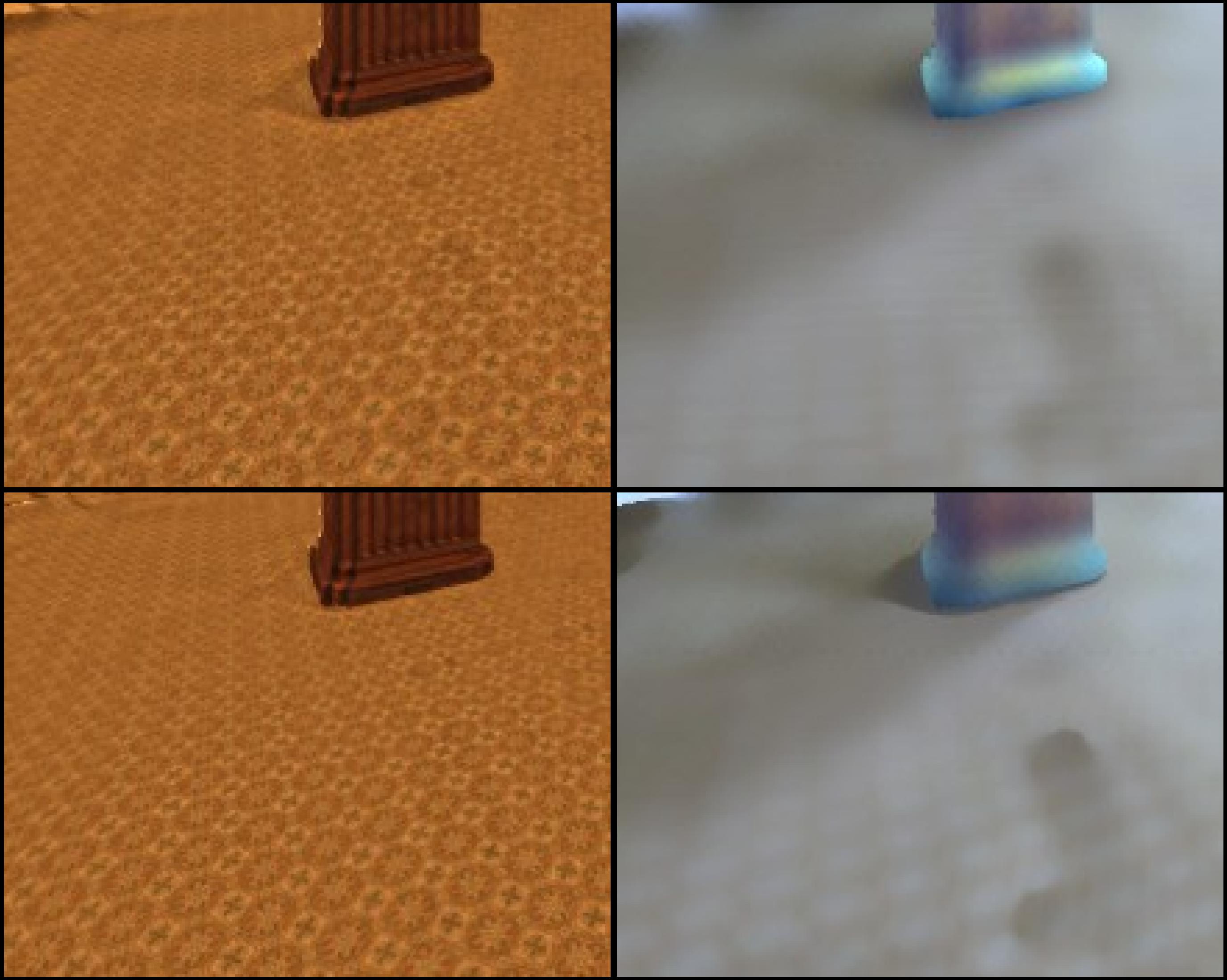
◻ pixel

○ kernel size



input image

Edge-Preserving Filter



texture

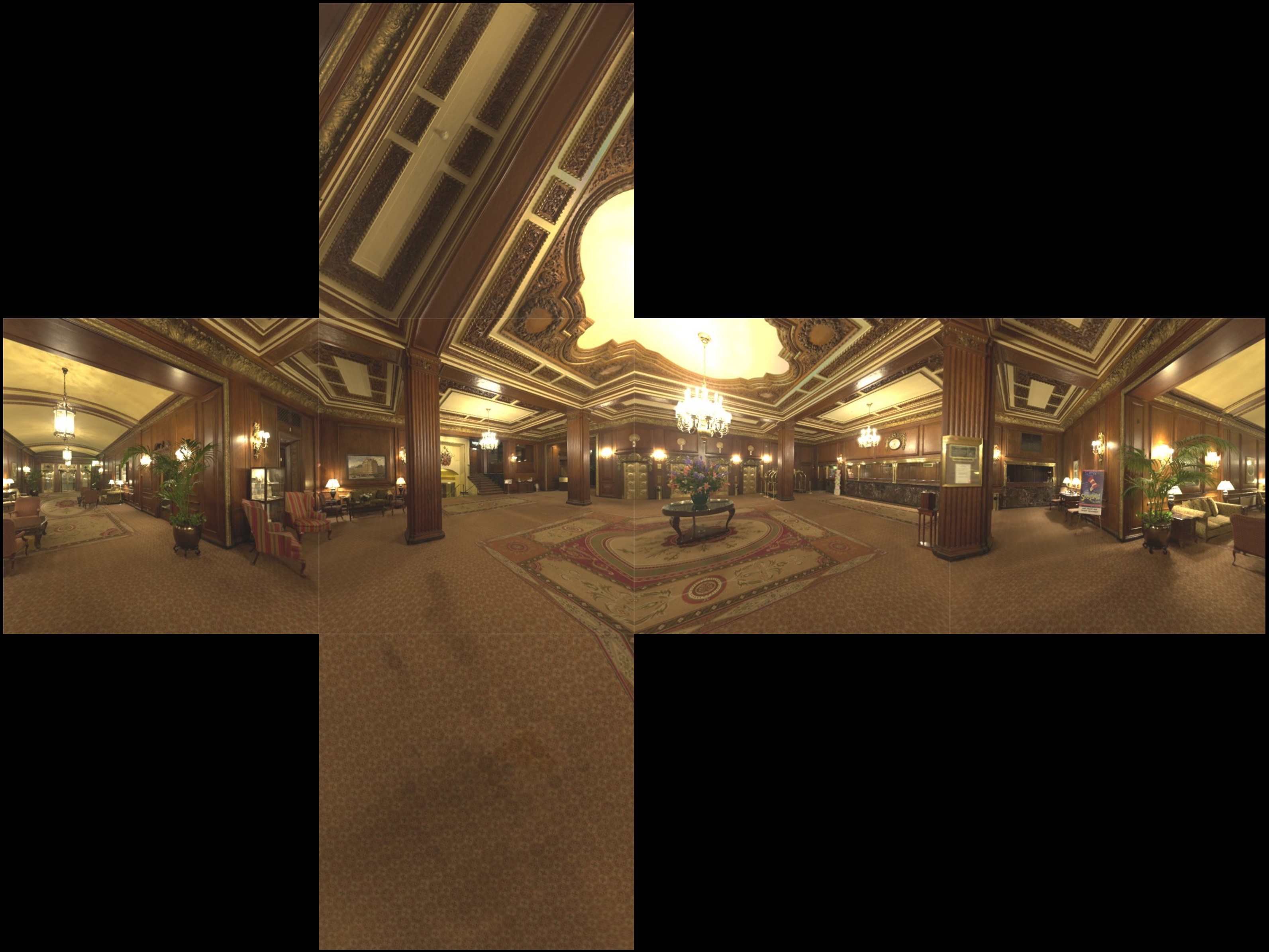
illuminance

Naïve

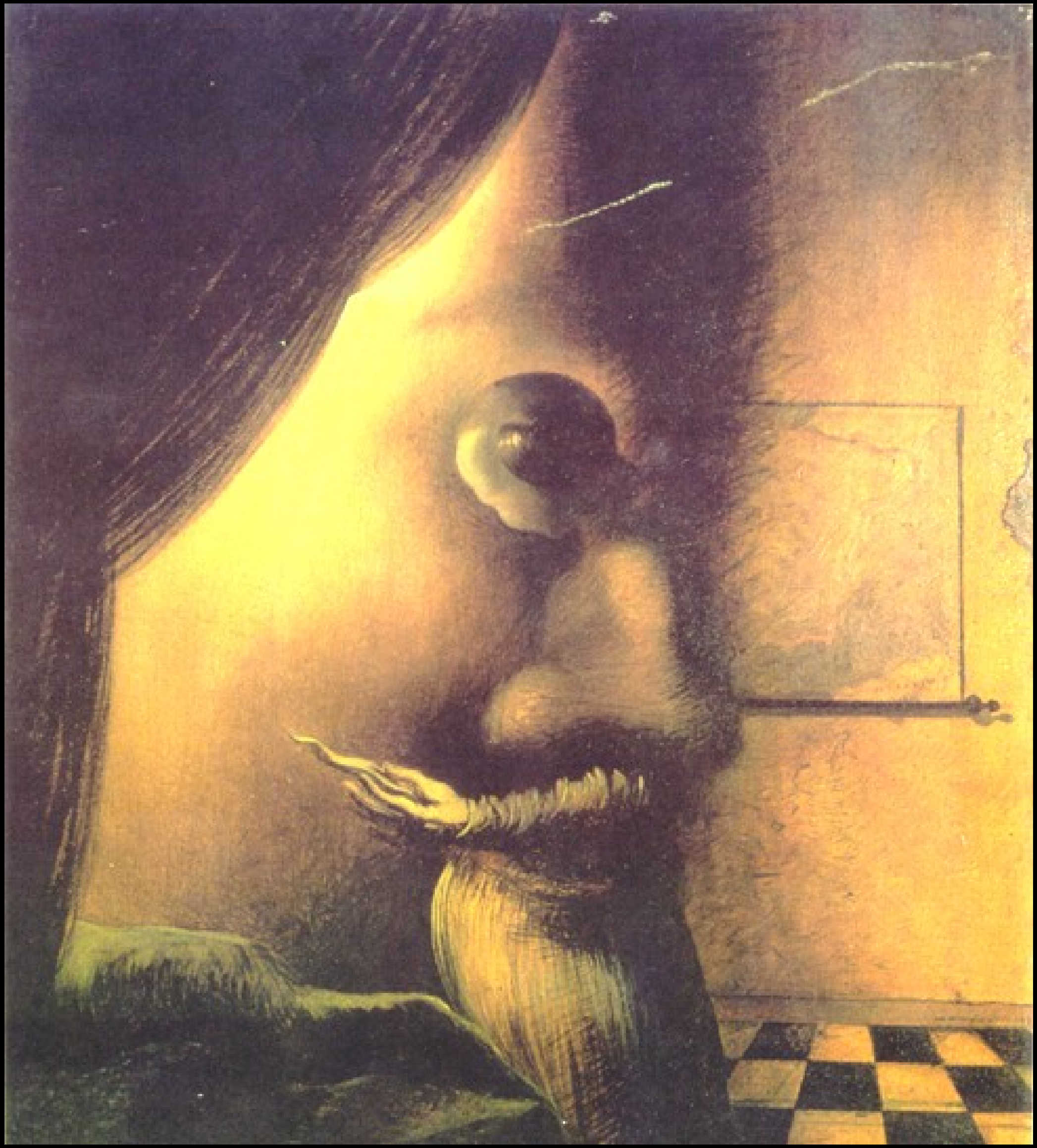
Edge preserving

A Simple Relighting Example

Results – Hotel Lobby



Results – A Painting by Dali



Conclusion

Image-based modeling & photo-editing system

Single image as input

Layers of images with depth

Depth assignment tools

Non-distorted clone brushing

Texture-illuminance decoupling

Future Work

Incorporate other techniques

- e.g. shape from shading, stereo, filters

Multiple images

- For modeling & larger walkthroughs

View-dependent effects

Applications

- e.g. special effects, design, virtual TV sets

Thank You

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